Science: It's Elementary

Year Two Evaluation Report

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INTRODUCTION

This report summarizes the activities and findings of the external evaluation of the *Science: It's Elementary* (SIE) program in the period June 2007 through May 2008. In the program's second year, the evaluation collected data from a variety of sources using several types of instruments:

Questionnaires

- Administered a questionnaire to collect baseline data on the second cohort of participating teachers and schools;
- Administered a post-professional development questionnaire to gather teachers' opinions of the quality and impact of the professional development;
- Developed and administered an end-of-year questionnaire to examine the impacts of the SIE program on teachers and their teaching;
- Developed and administered a questionnaire for principals of participating schools;
- Administered a curriculum survey to Cohort 2 teachers;
- Developed and administered a curriculum alignment survey for district science supervisors/curriculum coordinators;

Observations

- Observed a sample of 36 professional development sessions to examine the quality of the training provided to teachers;
- Conducted 48 classroom observations to examine the fidelity and quality with which teachers were implementing the SIE-provided modules;

Interviews

- Interviewed a sample of 27 teachers participating in the SIE program;
- Interviewed a sample of 40 principals (20 from each cohort) whose schools are participating in the SIE program;
- Interviewed a sample of 20 district science supervisors/curriculum coordinators;[1]

Assessments

- Developed and administered four assessments of teacher content knowledge;
- Developed seven student assessment scales related to science curriculum modules being provided by the program;
- Administered student assessments for both the Fall 2007 and Spring 2008 module implementations in schools participating in the program; and
- Observed the June 2008 leadership conference designed to prepare teacher leaders to provide professional development in future years of the program.

[1] For each set of interviews, HRI drew a random initial sample and made repeated attempts to interview everyone in the sample. HRI randomly selected additional participants as needed to make up for non-response. In an attempt to interview 40 teachers (20 from each cohort), over 100 teachers were contacted via email and telephone. Seventy-seven principals and 23 district science supervisors were contacted to reach the targeted goal of 40 and 20 interviews, respectively.

After a brief description of the SIE program and the evaluation plan, this report describes the status of the teachers, schools, and districts participating in SIE; the nature and quality of the services provided by the program; and preliminary evidence of the program's impact on teachers, their teaching, and their students. The report concludes with a summary of major achievements and presents HRI's recommendations for the program.

OVERVIEW OF *SCIENCE: IT'S ELEMENTARY*

The SIE program is managed by ASSET Inc. and overseen by the Pennsylvania Department of Education. SIE is an initiative aimed at improving elementary science instruction across the commonwealth of Pennsylvania. The program is focused on helping schools and districts implement an inquiry-based, hands-on science education program, with the ultimate goal of improving student learning. To accomplish its goals, SIE provides participating schools with module-based science instructional materials; teacher professional development around specific modules and inquiry-based science teaching more generally; and opportunities for strategic planning to help create supportive systems for science education reform. The program has six main components:

1. Strategic Planning Institute: Based on the National Science Resource Center's LASER model, these institutes are intended to help schools and districts understand, plan for, and successfully implement inquiry-based elementary science programs. Each school participating in SIE sends a team comprised of administrators, teachers, and community partners to the Strategic Planning Institute to learn about science education reform and to develop a three-year strategic plan for their school.

2. Vision Conference: This one-day event for school, district, and community leaders is intended to help foster a common, long-term vision for science education among a larger and more diverse group of stakeholders than the Strategic Planning Institute. Attendees include superintendents, district administrators, school board members, principals, and community representatives.

3. Teacher Professional Development: Each teacher responsible for teaching one of the SIE-provided science modules is expected to attend an initial three-day training focused on that module. This training provides teachers with an opportunity to familiarize themselves with the instructional materials; receive practical tips for using them in their classrooms; and learn teaching strategies such as inquiry, questioning for higher learning, and integrating science and literacy through the use of science notebooks. In the second year of the program, teachers are offered a two-day follow-up training on the same module to reflect upon their initial implementation of the module and to learn more about the related science content. These teachers also begin the professional development cycle again for a second module.

4. Delivery of Classroom Science Materials: In addition to the professional development, the SIE program delivers the science modules directly to schools for teachers to use in their classrooms. After instruction with the modules is completed, the modules are returned and are refurbished for use again the following year.

5. Leadership Conference: This five-day conference is intended to help develop the capacity of teachers selected by schools participating in SIE to become teacher leaders who can mentor and coach other teachers in their schools and districts. The program also expects that some of these teacher leaders will be able to serve as module trainers in future years.

6. Showcase of Student Learning: To help build community support for science education improvement, SIE encourages each participating school to host a Showcase of Student Learning. During this event, parents, community members, and other stakeholders are engaged in science activities that highlight the hands-on, inquiry approach. These activities are typically led by students who have experienced this approach in their science instruction. SIE provides materials and support to schools for hosting this event.

Figure 1 shows the program's theory of action, i.e., how program activities are intended to fit together to produce the desired short- and long-term outcomes.

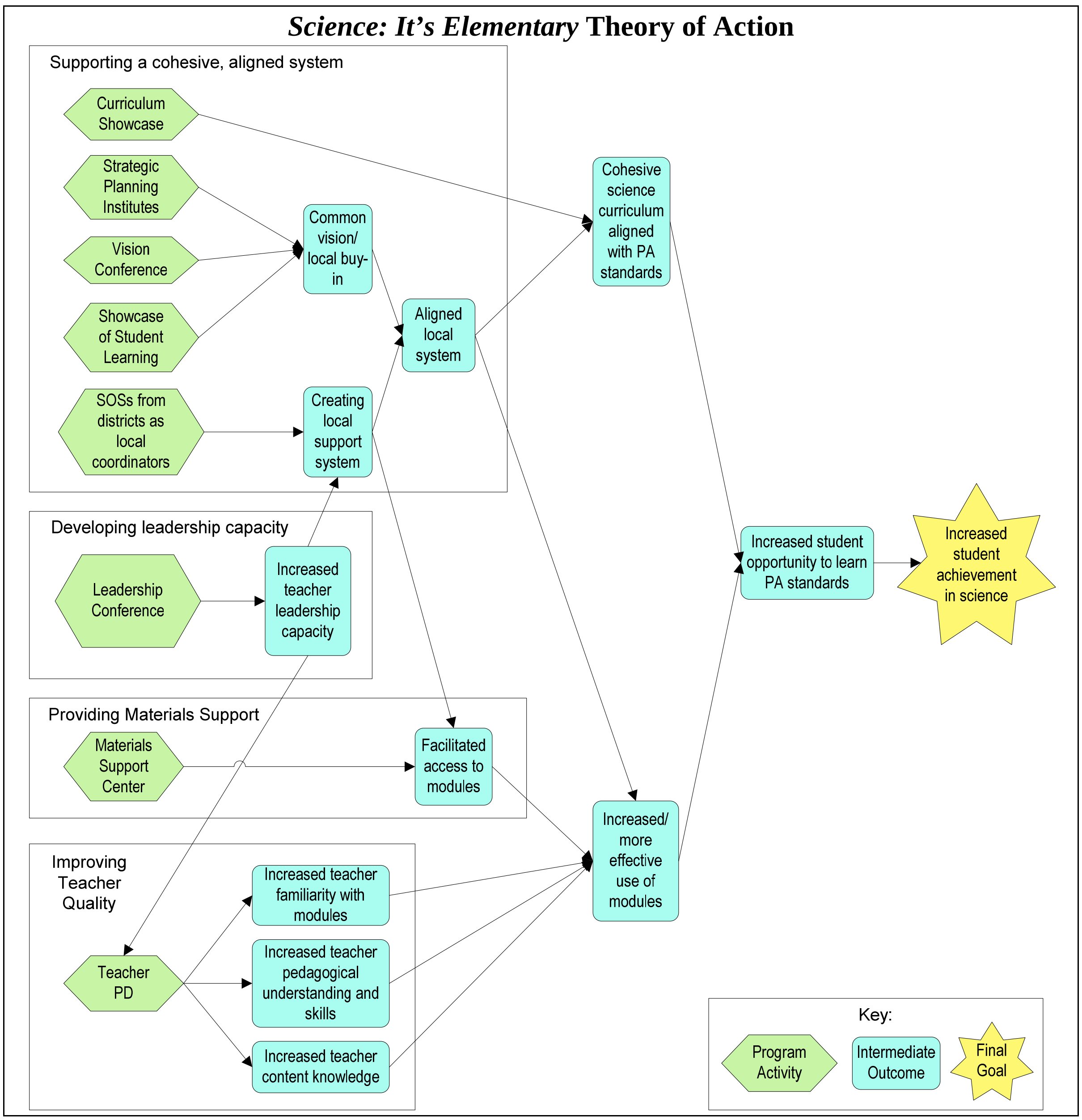

Figure 1

In addition, the SIE program requires each school to designate a Support On Site person (SOS). The SOS serves as the main conduit between the SIE program and the school, both for passing along important information from the program to the teachers and for helping teachers resolve any problems with the modules or professional development that may arise. The SOS is also responsible for registering teachers for SIE professional development and coordinating evaluation activities for the school.

In Year Two, SIE added a second cohort of schools to the program. In total, over 2,000 teachers in 124 schools participated in the SIE program this year. Table 1 shows the distribution of schools across the education regions in Pennsylvania.

Table 1
Distribution of Schools Participating in SIE

		Number of Schools		
	Region	**Total**	**Cohort 1**	**Cohort 2**
East	1	18	10	8
	2	7	4	3
	3	7	4	3
Central	4	9	5	4
	5	16	9	7
	6	22	11	11
West	7	21	9	12
	8	24	15	9
	Total	**124**	**67**	**57**

OVERVIEW OF THE SIE EVALUATION

The evaluation plan for SIE was developed by HRI in conjunction with key stakeholders with the goal of examining the major elements of the program's theory of action. The questions driving the evaluation focus on four main areas: (1) the development of an aligned system to support effective science education; (2) professional development for teachers; (3) the impacts of the program on teachers and their teaching; (4) and the impacts of the program on students. The key evaluation questions, by area, are:

System Alignment

1. How effectively is SIE assisting schools in the development of a coherent, cohesive, and aligned system to support elementary science education improvement?

Professional Development

2. What is the quality of SIE professional development provided to teachers?

Impacts on Teachers and Their Teaching

3. What is the impact of SIE on teacher knowledge and skills?

4. What is the impact of SIE on teachers' implementation of the modules?

5. What is the impact of SIE on student opportunity to learn the Pennsylvania science standards?

Impacts on Students

6. What is the impact of SIE on student achievement in science?

This report provides initial answers to these questions based upon the program's activities in Year Two.

SUPPORTING A COHERENT, COHESIVE, AND ALIGNED SYSTEM FOR ELEMENTARY SCIENCE EDUCATION IMPROVEMENT

Although enabling schools and districts to create an aligned system is beyond the scope of SIE's mandate, the school and district contexts in which the program is being implemented will likely factor into the success of the program. A number of evaluation activities provide data that shed light on how these contexts are impacting SIE's efforts to improve science education.

Reasons for Participating in SIE

A questionnaire administered to the principals of schools in the SIE program asked why they decided to participate. Principals indicated a desire to improve the science program in their schools, in particular making it more inquiry-based, as the main motivator for applying for the SIE grant. Nearly three-quarters of the responding principals indicated that the SIE professional development and instructional modules were important factors in their decision to join the program. (See Table 2.)

Table 2
Reasons for Joining SIE

	Percent of Responding Principals†		
	Overall (N = 93)	**Cohort 1 (N = 48)**	**Cohort 2 (N = 45)**
Access to the SIE professional development	74	74	73
Access to the SIE-supported science modules/kits	72	79	64
Our school's interest in increasing the amount of inquiry-based science taught	71	83	58
The district's interest in participating	69	77	60
My (the principal) interest in participating	68	65	71
Our school's interest in increasing our teachers' science content knowledge	67	68	67
The new science PSSA	53	55	51
The SIE program's alignment with our district's vision for its science program	53	63	42
Our school's interest in increasing instructional time devoted to science	48	56	40
Our teachers' interest in participating	29	38	20

† Includes only those indicating a "4" on a four-point scale of 1 "Not at All" to 4 "To a Great Extent."

Interestingly, although only about half of the principals indicated that the new science PSSA greatly influenced their decision to join SIE, nearly all of the interviewed district science supervisors indicated that it was a factor, though some noted that they had mixed feelings about the assessment. As two said:

> *The motivating factor, obviously, [is] the accountability with the PSSA assessment in science.*

> *As much as I hate to say it, the science PSSA.*

Baseline Status of Cohort 2 Schools' Science Programs

Overall, the science programs of Cohort 2 schools (i.e., those joining SIE in Year Two) before joining SIE were very similar to Cohort 1 schools when they joined the program last year. On a district curriculum alignment questionnaire completed by 48 of the 57 Cohort 2 districts, only 69 percent of respondents indicated that their district had a curriculum guide for science in grades K–6. (A copy of the baseline district curriculum alignment questionnaire and frequency distributions are included in Appendix A.) In nearly all of these districts, the curriculum guide is intended to support teachers in the selection of topics to teach and instructional materials to use; however, other data indicate that the intended curriculum is not always being enacted.

A baseline questionnaire administered to teachers at the beginning of their SIE training, as well as interviews with a random sample of principals, indicate that both the emphasis given to, and the quality of, prior elementary science instruction was inconsistent, at best. When asked to describe the strengths of their school's science program, one of the most common responses, given by nearly one-fifth of responding teachers, was some version of "our school does not have a science program." Often, the lack of a science program was attributed to a heavy focus on reading/language arts and mathematics due accountability pressures in those areas. Other teachers indicated that, although science is taught, there is no set curriculum for science. Principals also acknowledged that the discretion given to teachers often resulted in science being deemphasized. Typical responses included:

> *Our district focuses on reading and math. The elementary [level] has a limited science program.* [Teacher]
>
> *Our program currently has no strengths. It is inconsistent. We have no materials and no time allotted for science.* [Teacher]
>
> *Well basically our science program was in poor condition. Our curriculum was not aligned to the standards. We had focused mainly on reading and math and writing. The reason why we got in* Science: It's Elementary *is because we were just starting to look at our science curriculum which needs to be revised.* [Principal]

These kinds of concerns were echoed by district science supervisors. In interviews, many science supervisors stated that they thought teachers were spending the vast majority of their instructional time on mathematics and reading due to the high-stakes nature of the PSSA in those subjects.

The relative lack of emphasis on science instruction prior to SIE participation is also evident from teacher responses to close-ended items on the questionnaire. As can be seen in Table 3, fewer than half of the teachers indicated teaching science four or five times per week. The length of science lessons varied greatly, with most lasting between 21 and 50 minutes. Taken together, these responses translate to an average of 22 minutes of science instruction per day.

Table 3
Time Devoted to Science Instruction Prior to SIE in Cohort 2 Schools

	Percent of Teachers (N = 1,026)
Science Lessons per Week	
0	7
1	11
2	14
3	26
4	17
5	25
Minutes per Lesson	
10 or fewer	5
11–20	9
21–30	29
31–40	29
41–50	20
51 or more	8

Interview responses noting strengths of pre-SIE science programs varied greatly and few strong themes emerged. About 1 in 3 teachers thought that their existing instructional materials were of high quality; roughly half of these teachers had previously used kits like those provided by SIE. Other responses, each given by a handful of teachers, included the quality of district support staff, and teachers' positive attitudes toward teaching science.

When asked in what ways their school science program could be improved, teachers typically focused on allocating more time for science teaching, access to materials for teaching science, and/or increased use of hands-on science instruction. Typical responses included:

> *We would need to lengthen the day in order to teach an appropriate science program. The reading and math programs that we follow take up at least 90 percent of our teaching day.*

> *[A] stronger thematic approach developed from pre-K up. We should work together to build on concepts and themes, and be able to do more experimentation.*

In order to help examine curriculum alignment with the state standards, and to provide data that could assist schools, districts, and the Pennsylvania Department of Education (PDE) with curriculum planning, a teacher curriculum survey was administered to all teachers in the Cohort 2 SIE schools responsible for teaching science.[2] The survey was modeled after the Surveys of Enacted Curriculum,[3] asking teachers how much instructional time was devoted to the various Pennsylvania science standards and the nature of that instruction.

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[2] The questionnaire was conducted on-line, with each school's Support on Site person (SOS) responsible for administering it to the teachers at the school. Of the 1,027 teachers registered for the survey by their SOS, 873 completed the questionnaire, a response rate of 85 percent.

[3] Blank, R. K., Porter, A., & Smithson, J. (2001). *New tools for analyzing teaching, curriculum and standards in mathematics and science: Results from survey of enacted curriculum project, final report*. Washington, DC: Council of Chief State School Officers.

Table 4 shows the amount of instructional time teachers reported devoting to the *Science and Technology* and *Environment and Ecology* standards, disaggregated by grade level expectations. Overall, about two-thirds of instructional time is reportedly spent on *Science and Technology* standards, and one-third on *Environment and Ecology* standards.

Table 4
Instructional Time Devoted to Categories of Standards in Cohort 2 Schools, by Grade Range

	Percent of Instructional Time		
	All Teachers (N = 873)	**K–4 Teachers (N = 728)**	**5–6 Teachers (N = 145)**
4th Grade Science and Technology	35	35	35
4th Grade Environment and Ecology	21	21	16
7th Grade Science and Technology	30	29	36
7th Grade Environment and Ecology	15	15	13

It is interesting to note that grades K–4 teachers reported spending 44 percent of their instructional time on standards that the state designates as those to be addressed in grades 5–7; grades 5–6 teachers reported devoting over 50 percent of their science instruction to 4th grade standards.

Although one would expect some instructional time to be “off grade level” (e.g., for reinforcement, extensions, and making connections), these data seem to indicate that at this point the enacted curricula in many of the schools participating in the SIE program are not well aligned with the state standards. Additional data from this survey, disaggregated by major topic area (e.g., Inquiry and Design; Biological Sciences, Earth Sciences), are presented in Appendix B.

It will be important for schools, districts, and PDE to consider how well the data from this survey match their vision for science curriculum, and what steps, if any, should be taken to improve alignment.[4] In addition, it is HRI’s experience that most teachers do not have the time or training to develop high-quality curriculum materials. Thus, the SIE program may want to consider ways to assist schools and districts in developing curricula that are well aligned with the state science standards.

[4] To facilitate such work, HRI has made each SIE school’s data available to school personnel via the on-line system created for the curriculum survey. In addition, PDE has access to all schools’ data, individually and in aggregate, via the on-line system.

Status of Cohort 1 Schools' Science Programs

Although Cohort 2 schools were just beginning the process of improving their science programs, Cohort 1 schools were in their second year of the process. In interviews, a sample of 20 principals of Cohort 1 schools was asked about changes that have occurred in their schools since joining SIE. Several of the interviewed principals indicated that their science program had changed to a more hands-on, inquiry-based approach to science. A typical response was:

> *Before, there was a lot of reading, recall from textbooks. Now it's a lot of hands-on.*

In addition, most of the principals indicated that the amount of instructional time devoted to science had increased. Some principals indicated that the school now has a scheduled time for science. Others indicated that the school had lengthened the time schedule for science. As one principal said:

> *Before, science was one of the subjects that if we ran out of time, it would be cut, you know, so that they could do more with reading or math. And now, science has a scheduled time.*

Although most principals thought the increased emphasis on science was a positive outcome, a few expressed concern about the increased time, particularly in kindergarten and the early elementary grades. As one principal said when asked if there had been changes to the amount of time devoted to science:

> *Oh, definitely. They [teachers] have no choice but to spend more time on it, which is very stressful…especially in the primary grades. The primary grades are really struggling with the amount of time it takes to do the modules. And we have kindergarteners here for just a tad over two hours. And they have a half an hour expressive arts time in that block. So when do you do all of your literacy, your math and now in addition a forty-five minute science?*

Principals were also asked if there had been changes in the science topics taught in their schools. Several principals noted that a greater number of science topics were being taught. Others indicated that science is now covered at greater depth and that their science curriculum is better aligned with state standards. Principals generally attributed these changes to the implementation of the SIE-provided modules, and indicated that the SIE professional development enabled these changes to occur. As one principal commented:

> *I have never had 20 teachers go out to a training, and every single one of them came back with glowing remarks about the training, about how excited they were to have that training.*

Finally, many of the principals noted a renewed excitement for science in their students, and that this enthusiasm has even gotten parents excited about science. As three principals said:

You know the kids love it. I think it makes a difference for everybody. The kids enjoy it, they talk about it, they're actually really engaged in it and you know that makes it worth it to everybody.

The kids are excited about science. They get excited when they know they're starting the modules.

And I think the children are going home and even amazing their parents. [A child's] mother says to me, "Oh, my goodness, the things he comes home and talks about and can really explain it."

Three-quarters of the interviewed principals indicated that one of their teachers had been trained as an SIE teacher leader in last year's leadership conference; most of these indicated that this teacher leader acted as a resource person for other teachers in their school, helping other teachers with the implementation of the modules; about half reported that the teacher leaders had taken on other responsibilities in the school as well such as serving on the science fair committee, acting as the SOS, and answering parents' questions about SIE. Comments about the teacher leaders included:

She's looked at definitely in my building as much more of a resource person, she's able to answer a lot of the questions as the teachers are going through the kits.

[The teacher leader is seen as a] mentor, a facilitator, someone they can go to with questions; people view her as the expert.

The sole drawback to the teacher leader portion of the program identified by the principals was the amount of time the teacher leader was taken out of the classroom. As one principal said:

They're out of the class for the training more. And that's the killer in this whole thing.

Factors Affecting Science Program Improvement

On a questionnaire, principals of both cohorts were asked about factors that facilitate or inhibit their school's science program. As can be seen in Table 5, nearly all principals indicated that access to professional development for teachers as well as the quality and availability of resources for science instruction (presumably those being provided by SIE) were facilitators of science instruction. State and district science curriculum frameworks were also frequently seen as helpful. State and district testing policies in subjects other than science were the most frequently mentioned inhibitors, though these were selected by only 1 in 5, or fewer, principals.

Table 5
Principal Opinions of Factors that Affect Science Instruction

	Percent of Responding Principals (N = 93)	
	Facilitates†	Inhibits‡
Access to professional development for science	92	7
Quality of resources for science instruction	90	5
Availability of resources for science instruction	89	9
District science curriculum frameworks	85	3
State science curriculum frameworks	85	5
State science testing policies and practices	81	10
Importance that the district places on science instruction	77	3
Consistency of science reform efforts with other district/school reforms	70	4
State testing policies and practices in subjects other than science	62	20
District science testing policies and practices	60	3
District testing policies and practices in subjects other than science	57	15
District grading policies and practices	47	8
District policies for evaluating teachers	39	2
District structures for recognizing and rewarding teachers	24	2

† Includes those responding "Somewhat Facilitates" or "Greatly Facilitates."
‡ Includes those responding "Somewhat Inhibits" or "Greatly Inhibits."

Principals were also asked what additional services the SIE program could provide that would help them support their school's science program. Ideas for securing resources for science instruction; creating opportunities for teacher collaboration; assessing progress of the school's science program; integrating science with mathematics and literacy; and providing feedback to teachers were each mentioned by roughly 60 percent of principals. (See Table 6.)

Table 6
Principals Indicating that Potential Program Services Would be Very Valuable

	Percent of Responding Principals		
	Overall (N = 93)	Cohort 1 (N = 48)	Cohort 2 (N = 45)
Ideas and tools for securing the resources needed for science instruction	63	57	70
Ideas and tools for creating opportunities for teacher collaboration	62	56	69
Ideas and tools for assessing progress of our school's science program	61	63	60
Professional development for me to increase my own understanding of how to integrate science with mathematics and literacy	60	56	64
Ideas and tools for observing and providing feedback to teachers about their science instruction	59	56	62
Ideas and tools for increasing parental support/interest/involvement in our school's science program	46	48	44
Professional development for me to increase my own understanding of effective science teaching	43	46	40
Ideas and tools for increasing community support/interest/involvement in our school's science program	42	42	43
Ideas and tools for leveraging other district resources (e.g., professional development days) to support science instruction	42	33	51
Ideas and tools for making science more of a priority in the school	39	33	44
Professional development for me to increase my own science content knowledge	25	29	20

The Strategic Planning Institute and Vision Conference

The Strategic Planning Institute (SPI), and to a lesser extent the Vision Conference, are SIE's main activities for helping schools new to the program develop a common vision for science instruction, as well as a plan for making that vision a reality. The SPI is a five-day event modeled after the National Science Resource Center's LASER Institute. Each SIE school was invited to send a five-person team to the SPI, ideally a mix of district administrators, school administrators, teachers, and community representatives. The SPI had six main goals:

1. Develop a shared vision about effective science teaching and learning;

2. Design models for developing and sustaining a corps of leaders for improving the teaching and learning of science;

3. Apply knowledge about the five components of an effective school-based infrastructure needed to support a research-based science program (i.e., standards-based materials, professional development, centralized materials support, assessment, and community/administrative involvement);

4. Develop a strategic plan for improving instruction in science that is informed by research, incorporates best practices, and leverages change through partnerships;

5. Assess and incorporate local, state, regional, and national resources that will contribute to the implementation and sustainability of a research-based science program; and

6. Become members of a network of informed professionals working to increase student achievement through the implementation of effective science programs.

To help accomplish these goals, the SPI offered a number of sessions that focused on topics such as systemic change, research about science teaching and learning, the FOSS and STC modules that are part of the SIE program, and research about effective professional development. The SPI also provided time for teams to generate a strategic plan for improving science education in their schools and districts.

Interviews with principals, teachers, and district science supervisors indicate that attendees benefited from the SPI. Many of the interviewees reported that it was helpful to have time to sit down as a team and think about their science program, including looking at both what was taught in their schools and how it was taught, as was having the opportunity to begin developing a plan for improving their science program.

> *The Strategic Planning Institute was a real eye-opening experience for us because it gave us the opportunity to sit down and make some long-term decisions about where science is going. It was a good week. It was very informative and lots of good networking was done, not only amongst the people that we brought from our district, but with other districts. It provided a lot of information that I brought back to the board and it really helped build the momentum for this project.* [District Science Supervisor]

[We got] a better layout, a better feel for what was going to really be needed to implement this and make sure that our teachers bought into it…[The SPI] laid the groundwork for successful implementation. [Principal]

It gave us a great oversight of the entire program…It also allowed us to look at the different modules, trying to decide where our weakness was as a school and the content that we needed to pick to strengthen our curriculum, and by looking at those modules that were on display helped a great deal. We were able to pick the module that we felt best suited our curriculum at each grade level. We came back with a good plan…good vision that we could explain to our community and our fellow teachers, what this Science: It's Elementary *is all about.* [Teacher]

The major concern about the SPI, arising from all three sets of interviews, was that it required too great a time commitment. A number of the attendees also indicated that the SPI devoted too much time to trying to convince them of the value of the program, which they thought was unnecessary given they had applied to be part of SIE. As one district science supervisor said:

We heard a lot of things that were being said, or presented, to sell us on inquiry-based instruction. We didn't need to hear that because we already know that that's what we wanted to do, and knew the importance, etc.

It would be advisable for SIE to re-examine the agenda of the SPI to determine whether and how elements can be condensed or modified to be more intentional in helping participants develop a common vision of effective science instruction, in particular downplaying efforts to "sell" them on the program.

The Vision Conference is a one-day event designed to help build support for an improved science education program among a larger and more diverse group of stakeholders than the SPI participants. Attendees included superintendents, district administrators, school board members, community representatives, and principals of participating schools. According to interviewees, the Vision Conference was effective at building a broader base of support for the program. The following response was typical:

Just seeing what the vision was for the program [was helpful]. You know, the beliefs in the teaching methods that are being used, how to get the community more involved in the program… [Principal]

The most commonly mentioned suggestion for improving the Vision Conference centered on its redundancy with the SPI. Although the Vision Conference is aimed at a broader audience than the SPI, many schools sent the same people to both events. Thus, the program may want to consider clarifying expectations as to who should attend which events and make sure to disseminate those expectations as early as possible. Another possibility would be to fold the Vision Conference into the SPI, inviting school board and community members to a day of the SPI that focused heavily on developing a vision for effective science instruction.

THE QUALITY OF SIE PROFESSIONAL DEVELOPMENT

The primary aim of the SIE program is to enhance student learning of science in K-6 classrooms by providing high quality instructional materials and professional development to help teachers implement those materials well. The consensus view among experts in the field is that professional development needs to be sustained over time, situated in teachers' classroom practice, and focused on issues of curriculum and pedagogy related to the learning of specific content.[5] Professional development should also model and then explicitly discuss effective instruction and involve multiple stakeholders within schools.

The design of the SIE professional development program incorporates this wisdom of practice by providing teachers with a sequence of opportunities to move from mechanical (novice use) to highly purposeful (expert use) implementers of the instructional materials. **Error! Reference source not found.** summarizes the knowledge and skills HRI thinks teachers need to purposefully implement a module.

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[5] See for example: Elmore, R. F. (2002). *Bridging the gap between standards and achievement: The imperative for professional development in education.* Washington, DC: Albert Shanker Institute.

Banilower, E. R., Boyd, S. E., Pasley, J. D., & Weiss, I. R. (2006). *Lessons from a decade of mathematics and science reform: A capstone report for the local systemic change through teacher enhancement initiative.* Chapel Hill, NC: Horizon Research, Inc.

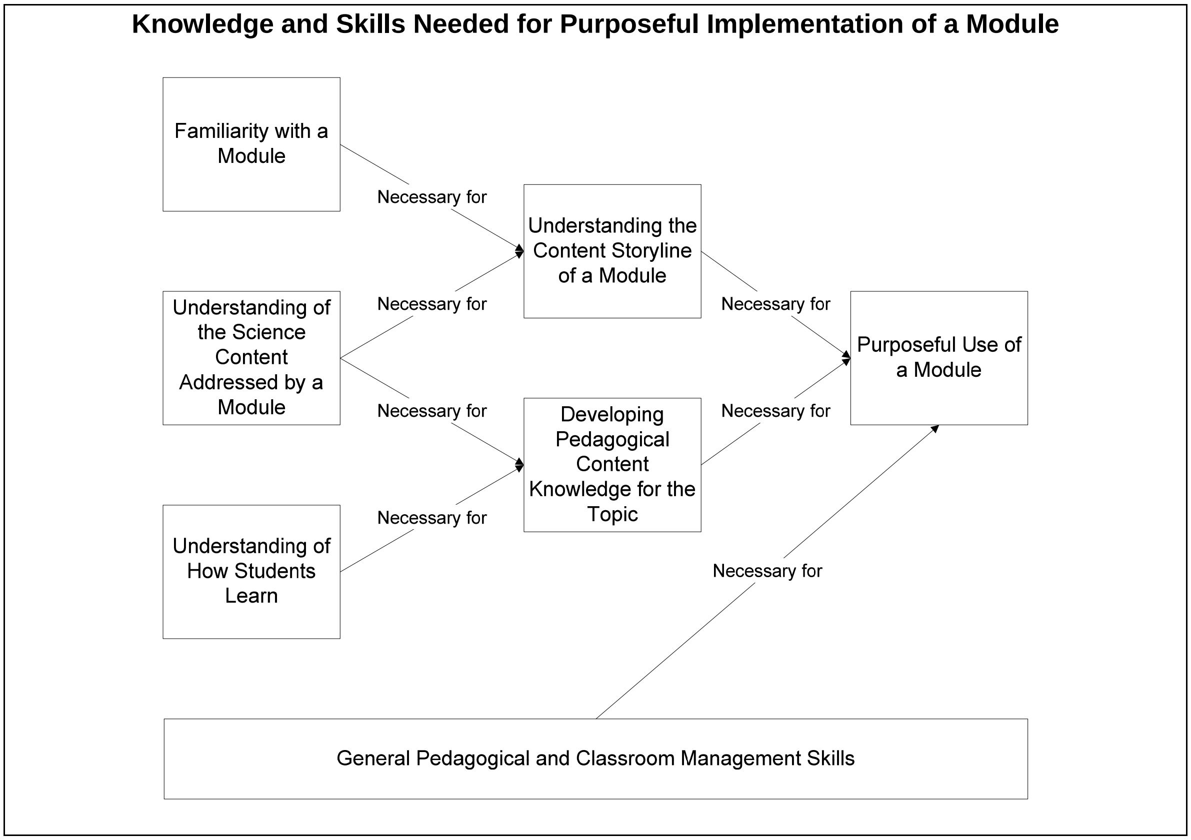
Knowledge and Skills Needed for Purposeful Implementation of a Module
Familiarity with a Module
Necessary for
Understanding the Content Storyline of a Module
Understanding of the Science Content Addressed by a Module
Necessary for
Necessary for
Purposeful Use of a Module
Necessary for
Developing Pedagogical Content Knowledge for the Topic
Necessary for
Understanding of How Students Learn
Necessary for
Necessary for
General Pedagogical and Classroom Management Skills

Figure 2

First, teachers need to know and feel comfortable with "what's in the box," i.e., the management of materials and students while using a module, including what the activities are in a module, how to set-up and use the provided equipment, and how students are supposed to interact with the materials.

Second, in order to effectively teach the science content to students, teachers must understand the content themselves. At a minimum, teachers should understand the ideas students are expected to learn, as well as how those ideas fit together in a coherent and cohesive framework (i.e., interrelationships among the ideas rather than isolated concepts or factoids) and build toward the "big ideas" of science. Teachers would also benefit by understanding the content beyond the student level, including how the ideas progress through the K–12 sequence, so they can guide students along productive paths of inquiry.

Third, in order to teach effectively, teachers need to have a clear understanding of how students learn science and an explicit vision of effective instruction. A great deal has been learned in the last few years about how people learn and the implications of research in the cognitive sciences for instruction.[6]

For instruction to be purposeful and effective, teachers need to be able to integrate their knowledge of the science content and their familiarity with the nuts and bolts of the module, understanding the "content storyline," how each of the scientific ideas addressed by the module is developed through specific learning experiences in the module. Ideally, teachers would be able to trace the development of a scientific idea through a module (e.g., students' initial ideas about a particular idea are elicited in activity 1; the idea is then developed in activity 2; students have an opportunity to practice and master the idea in activity 3).

Similarly, for instruction to be purposeful and effective, teachers need to be able to integrate their knowledge of the science content with their understanding of how students learn science. This type of knowledge is commonly referred to as pedagogical content knowledge and includes what initial ideas students are likely to have that may get in the way of their learning the targeted concepts (often termed "misconceptions" or "naïve ideas"), and specific strategies for helping students develop the correct ideas. For example, students often think that connecting a light bulb to one end of a battery will cause the bulb to light. A specific strategy for helping students move past this idea is to have them try many different configurations of connecting the bulb to the battery, recording which do and do not work, and then carefully analyzing the results to find the commonalities in the configurations that work, and the commonalities in those that do not work.

Finally, it is important to note that general pedagogical and classroom management skills are necessary for effective teaching of any topic. The SIE program is also attempting to broaden

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[6] National Research Council. (2000). *How people learn: Brain, mind, experience, and school.* J. D. Bransford, A. L. Brown, & R. R. Cocking (Eds.). Washington, DC: National Academy Press.

National Research Council. (2005). *How students learn: Science in the classroom.* M. S. Donovan & J. D. Bransford, (Eds.) Washington, DC: National Academy Press.

teachers' "tool bag" of skills, including ones that allow for the integration of reading/language arts instruction with the teaching of science (e.g., notebooking strategies).

In Year Two, SIE provided two types of professional development to address the needs of classroom teachers and work toward purposeful use of the modules. Initial Module Training was provided to teachers prior to their first implementation of a module. For teachers new to SIE, this training spans three days. The first day centers on orienting teachers to SIE, inquiry-based science teaching, and using science notebooks. The next two days focus on the SIE-provided module. Teachers being trained on additional modules attend only the latter two days of the Initial Module Training. The Initial Module Trainings are intended to help teachers attain at least a mechanical use of the module, and to lay the groundwork for further professional development that will move them toward more purposeful use.

SIE also offered two-day Module Enrichment Workshops in Year Two. Module Enrichment Workshops are intended to deepen the science and pedagogical content knowledge of teachers around the topics in a module. These workshops are aimed at teachers that have already attended the initial training and have implemented the module in their classrooms.[7] Most of the teachers attending the enrichment workshops in Year Two did so after attending the initial training on a second module. Table 7 shows the number of teachers completing the post-professional development teacher questionnaire at each type of workshop.

Table 7
Responses to Post-Professional Development Questionnaire

	Number of Teachers
Cohort 1, module enrichment on 1st module	590
Cohort 1, initial training on 2nd module	1,025
Cohort 2, initial training on 1st module	1,093

Initial Module Trainings

As noted above, the goal of the Initial Module Training workshops is to prepare teachers to use the instructional materials, including familiarizing them with the activities, the content taught in the activities, how the content is developed in the instructional materials, and strategies for engaging students with the content. Data for this section of the report come from questionnaires completed by teachers attending these trainings, interviews with a sample of 37 participating teachers, interviews with a sample of 40 principals, and observations of a sample of 26 workshops.

[7] The program has decided that teachers need more experience using the modules before they are ready to delve deeper into the content of the modules; thus, starting in 2008–09, Module Enrichment Workshops will be offered to teachers only after they have implemented a module twice in their classroom.

Teachers' Needs and Expectations

Knowing what participants' needs and expectations are for a professional development experience can provide valuable insight for understanding their perceptions of the quality of that experience. An open-ended item on the baseline questionnaire asked Cohort 2 teachers what they hoped to gain from participating in SIE professional development. The most common response, given by slightly less than half of Cohort 2 teachers, was that they were hoping to learn new instructional strategies. Teachers specifically mentioned learning more student-directed, hands-on, and inquiry techniques. Typical responses included:

> *New ideas to help students retain the knowledge they are learning in the hands on activities.*

> *Teaching strategies to be more effective, instructional practices in all areas of content, not just science.*

One-quarter of the participants indicated their primary concern was learning how to use the modules being provided by SIE. For example:

> *Just an idea [of] what the kit contains and what we're going to be teaching. How to implement the activities.*

> *I want to know what is involved in using the kits and how SIE will positively impact my students. I hope to gain knowledge on how to successfully use the kits.*

A handful of teachers also indicated that they were hoping to learn how to make science more enjoyable for their students. As two participants wrote:

> *I hope to learn activities that will help students understand science while making it fun and exciting.*

> *I am hoping to receive a module that is easy to use, interesting to my students, and will not require a lot of additional preparation time on my part.*

Data from teacher interviews coincide with the questionnaire data with one exception. A number of interviewed participants indicated that they were hoping for help on how to manage time effectively when using the materials. As one interviewee said when asked what expectations s/he had for the workshops:

> *How to put this system into the time that I have allotted to science…I don't have a whole lot of time for science, but I have to cover the same amount…do all these experiments, and…all the preparation.*

Teachers' Perceptions of the Quality of the Initial Module Trainings

Overall, teachers had very positive opinions about the SIE professional development. A questionnaire administered at the end of each session asked teachers about the quality of the training. As can be seen in Table 8, nearly all teachers thought the facilitators were well

prepared and encouraged active participation, and that they provided useful tips for successfully implementing the modules. In addition, the vast majority of teachers indicated that the Initial Module Training sessions increased their understanding of the science content and their familiarity with the activities in the modules.

Table 8
Teacher Opinions of the Quality of SIE Initial Module Training

	Percent Agreeing†	
	Cohort 1, 2nd Module (N = 1,093)	**Cohort 2, 1st Module (N = 1,025)**
The facilitators shared tips and suggestions for successfully implementing the module	95	98
The professional development increased my understanding of the science content in the module	95	95
The professional development familiarized me with the activities and materials in the module	95	97
The facilitators encouraged active participation and investigation by all participants	94	97
The goals of the professional development were clear	94	96
The professional development prepared me to use the teaching strategies promoted by SIE	94	95
The facilitators were well prepared	93	95
The professional development reflected careful planning and organization	93	95
Question about the science content in the module were adequately addressed by the facilitators	93	94
The various components of the training were useful in meeting the goals of this professional development	93	96
The facilitators modeled effective teaching strategies	92	94
The facilitators explicitly discussed how, when and why to use different teaching strategies	92	93
The professional development increased my confidence in my ability to teach using the SIE module	92	91
The professional development was relevant to my classroom instruction	92	90
There were opportunities for participants to express their vies and collaborate with peers	91	93
The professional development was worth the time that I invested	90	91
I would recommend this professional development to a colleague	90	90
Adequate time, structure, and guidance were provided for participants to reflect individually on the substance of the professional development	87	89
Adequate, time, structure, and guidance were provided for participants to discuss the SIE modules and pedagogical strategies with each other	86	87

† Includes those teachers agreeing or strongly agreeing with each statement.

Participants were also asked about the pace of the professional development. Roughly three-quarters of the teachers indicated that the pace was appropriate. (See Table 9.) Twenty-one percent of Cohort 2 teachers and 13 percent of Cohort 1 teachers found the pace of the Initial Module Trainings too slow; 10 percent of teachers indicated the pace was too fast.

Table 9
Teacher Opinions of the Pace of SIE Initial Module Trainings

	Percent of Teachers	
	Cohort 1, 2nd Module (N = 1,059)	**Cohort 2, 1st Module (N = 996)**
Much too slow	2	3
Somewhat too slow	12	18
Appropriate	77	69
Somewhat too fast	9	9
Much too fast	1	1

When asked in an open-ended question what aspects of the professional development were most helpful or effective, two-thirds of the responding teachers indicated going through the module and doing the activities as students. Quite a few respondents also mentioned the helpfulness of the facilitators sharing implementation strategies, and many described the collaboration with their colleagues. In interviews, both teachers and principals provided positive feedback about the professional development. Typical responses included:

> *I thought it was good that they had us actually doing the experiments and the observations that the children would be doing. And actually make the notebook so we could take that back with us and see what that would be like. Practicing new strategies that they presented to have the children share what they learned. Because it was hands-on, it was good for getting us ready to do it with the children.* [Teacher]

> *[It was helpful that the PD was provided] by teachers who had already taught the modules with students. I think that was good because they could tell us where the problems might be, or different ways of doing it to make our teaching easier with the different investigations. It was actually teachers who had gone through the modules themselves with students.* [Teacher]

> *The professional development really seemed to fit the needs of the teachers, giving them the content knowledge they needed, giving them the motivation they needed, and the instructional strategies they would need to implement it.* [Principal]

When interviewed teachers were asked how the professional development could be improved, their most common response was that it didn't need any changes, another indicator of their satisfaction with the workshops. Still, a number of teachers did have suggestions for improvement that are worth considering. Some participants indicated that the orientation to inquiry-based instruction on the first day of the three-day training wasn't as helpful as the rest of the training. For example:

> *I have to say that in the beginning, there was just a lot of preliminary stuff we probably could have done without, you know all that role playing and talking and all of that. Maybe cutting out some of that…some of the fluff and getting right to why you are there.*

Some teachers suggested that more time needed to be spent on the module and how they could implement it in their classrooms. As some of these teachers said:

> *We went through the beginning ones extensively, and when I was teaching them, I felt more comfortable with what was happening, but being that we sped through the last ones, I am a little bit apprehensive going into it. I feel like I need to prepare more.*
>
> *As far as how the training could've been made more useful, if they would've been able to address some issues about how to fit this in to various schedules, time management kind of things, that would be good.*

The end-of-year questionnaire also asked teachers what, if anything, the program could do to be more effective. The most common response among both Cohort 1 and Cohort 2 teachers centered on the logistics of the training sessions. Not surprisingly, teachers indicated they would prefer the trainings to be offered at locations closer to their homes and that the required training be shortened so they would be out of their classrooms fewer days. Teachers also indicated that the trainings would be more helpful if they occurred nearer to the time of module implementation. With the number of teachers served by the program and the costs associated with offering a training session, the program cannot offer trainings at locations and times ideal for every participant. However, given how busy teachers are and how difficult it is for them to be out of the classroom, the program may want to consider offering some trainings in the summer or on weekends.

Observers' Perceptions of the Quality of the Initial Module Trainings

Preparing teachers to implement a new instructional program is a major undertaking and a new science instructional program is particularly challenging. Many teachers (in Pennsylvania and across the nation) have put science instruction on the back burner, both because of relatively weak content backgrounds in science and high-stakes testing in mathematics and reading/language arts.

SIE's plan took into account research on teacher concerns suggesting that teachers using new instructional materials will first be concerned with the mechanics of the activities and their role in leading them, so initial training will necessarily be focused largely on familiarizing teachers with the basics of the module.[8] SIE's goals for the Initial Module Trainings were:

1. Introduce teachers to *Science: It's Elementary* (at the introductory day only);
2. Prepare teachers to implement the module at the mechanical level;
3. Deepen teachers' understanding of the content in the module at the student level;
4. Deepen teachers' understanding of the content storyline of the module; and
5. Prepare teachers to use instructional strategies, specifically notebooking and questioning, that support module implementation.

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[8] Hall, G. & Loucks, S. (1979). *Implementing innovations in schools: A concerns-based approach.* Austin, TX: Research and Development Center for Teacher Education, University of Texas.

Trained researchers observed 26 Initial Module Training sessions between October 2007 and January 2008. Table 10 shows the number of sessions observed for each module.

Table 10
Initial Module Trainings Observed

	Number of Sessions
Chemical Tests	3
Ecosystems	2
Electric Circuits	3
Environments	4
Human Body	4
Levers and Pulleys	3
Magnets and Motors	1
Mixtures and Solutions	1
Motion and Design	2
Plant Growth and Development	1
Rocks and Minerals	2

To examine the extent to which the SIE professional development provided teachers with opportunity to achieve the learning goals, HRI utilized a framework based on research on how people learn.[9] The framework specifies that effective science professional development provides accurate information about disciplinary content and the nature of science; enables participants to engage intellectually with important ideas; provides opportunities for participants to reflect on and make sense of the key ideas of the session; and provides opportunities for participants to relate the ideas in the session to their work as classroom teachers; all of which is facilitated by a collaborative culture. An analysis of SIE professional development by each of the program's specified goals follows.

- *Introducing teachers to* Science: It's Elementary

The initial day of training for Cohort 2 teachers focused on familiarizing them with SIE, module-based science instruction, inquiry, and literacy connections to science. Answering teachers' questions about SIE early on was especially important so that they could engage with the main goals of the module training. An icebreaker activity was used to identify participants' burning questions about SIE. Participants were asked to describe on pieces of chart paper around the room their current understanding, and any questions they had, about inquiry, science notebooks, science education reform, and the SIE program. This activity allowed facilitators to see where the group stood in their understanding of these topics, and to tailor the information they provided throughout the session to the information needs of the particular group.

Facilitators then provided an overview of the SIE program that explained the elements of science education reform as envisioned by the National Science Resources Center, and how the SIE program addresses these elements. Teachers had opportunities to ask questions about the program throughout the training, as facilitators utilized the "parking lot" strategy (teachers could

[9] HRI's frame for thinking about the quality of instruction for both adult and student learners is based upon the National Research Council's *How people learn: Brain, mind, experience, and school* (1999) and *How students learn: Science in the classroom* (2005).

post questions on chart paper that would be discussed when time allowed). These strategies for dealing with teachers' initial information needs appear to have been successful, allowing teachers to focus on the module-specific aspects of the training.

As part of the baseline and post-professional development questionnaires, HRI administered a set of items developed as part of the Concerns Based Adoption Model (CBAM). The theory holds that when teachers adopt a new curriculum or instructional approach, they progress through a series of concerns about the "innovation." As experience with the innovation grows, early concerns (e.g., being unfamiliar with the curriculum) are resolved, and later ones emerge. The implication of this stage theory is that early concerns must be resolved before later ones can be effectively addressed. The CBAM theory suggests that effective professional development specifically targets the concerns that are likely to emerge at different points in the adoption process. The seven stages of concern are operationalized in a 35-item CBAM questionnaire[10] developed to measure the intensity of each concern:

1. Awareness (e.g., I don't even know what the SIE modules are.)
2. Informational (e.g., I would like to know what resources are available for implementing the SIE modules.)
3. Personal (e.g., I would like to know how my teaching is supposed to change using the SIE modules.)
4. Management (e.g., I am concerned about my inability to manage all that the SIE modules require.)
5. Consequence (e.g., I am concerned about how the SIE modules affect students.)
6. Collaboration (e.g., I would like to develop a working relationship with both our faculty and outside faculty using SIE modules.)
7. Refocusing (e.g., I would like to modify our use of the SIE modules based on the experiences of our students.)

The hypothetical concerns profile in Figure 3 illustrates how early concerns (e.g., informational) are the most intense early in an implementation, but decrease over time, and are replaced by other concerns. It is important to note that in the CBAM theory, the changes depicted in Figure 3 can take two to three years to be observed.

[10] HRI modified the original CBAM questionnaire to tailor it for the SIE program.

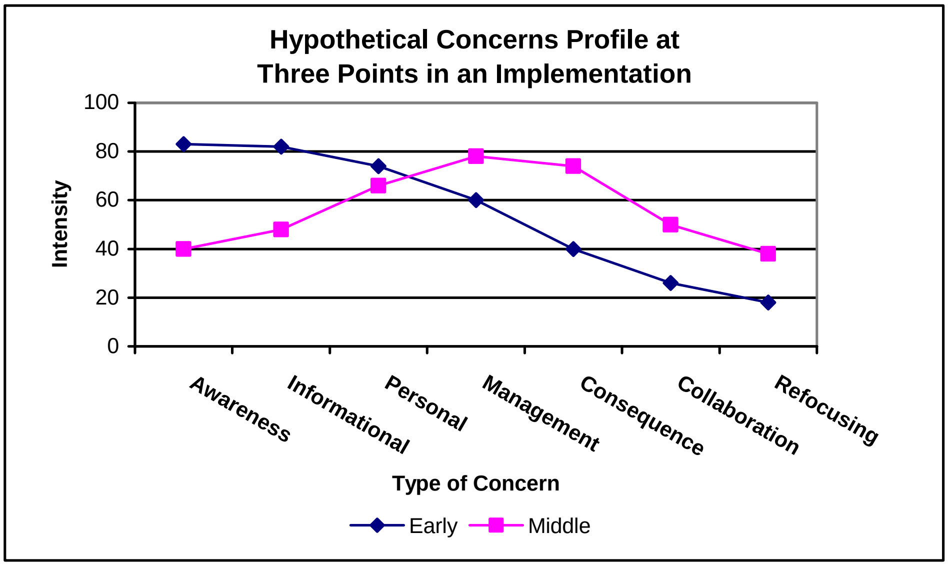
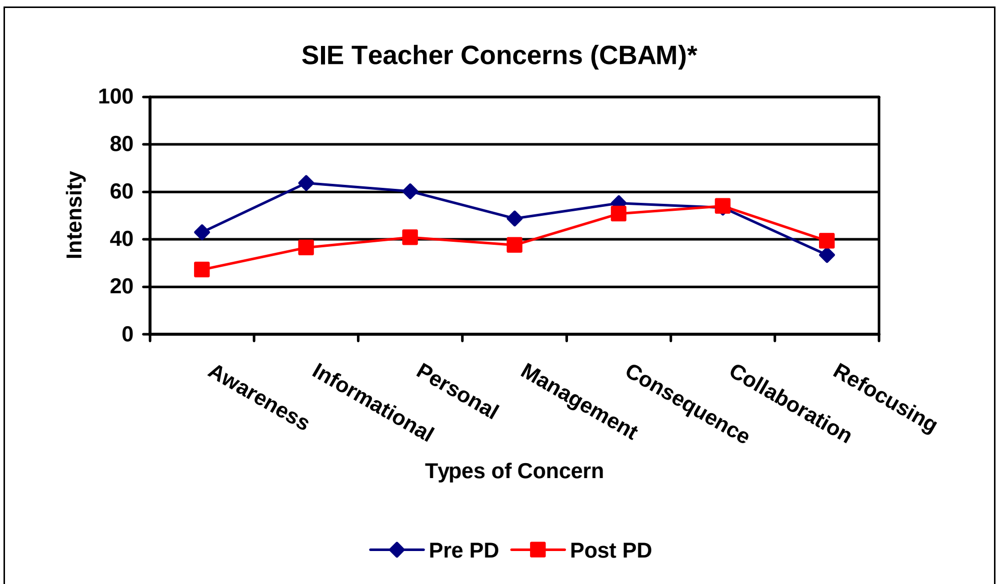


Figure 3

Figure 4 shows CBAM data from Cohort 2 teachers participating in SIE professional development. Based on these data, SIE was successful at addressing these teachers' initial concerns about the program and the implications for classroom practice; this pattern is nearly identical to that observed last year among Cohort 1 teachers.



* Post PD profile is significantly different than the Pre PD profile, p < 0.05 (MANOVA)

Figure 4

In addition, the concept of inquiry was introduced on the first day of each three-day training through a “gallery walk,” in which participants were asked to read a variety of definitions of inquiry and choose the one that most “spoke” to them. The facilitators then led a discussion, asking teachers to share their perspectives. Participants also experienced inquiry through an investigation on the first day.

Although these activities exposed participants to ideas and examples of inquiry, neither a definition of inquiry and its essential components, nor SIE’s vision for how inquiry is part of effective science instruction was made explicit in the observed sessions. When asked to share their own definitions of inquiry, typical participant responses were: “hands-on activities,” “a higher level of learning for students,” “a shift from passive learners to active learners,” “problem solving,” and “students generating questions to further their learning.” Although the program provides teachers with the National Research Council’s “Essential Features of Classroom Inquiry, and Their Variations,”[11] it’s not clear whether participants were given sufficient opportunity to engage with these ideas in the time allotted. As a result, they may have completed the training still lacking a clear idea of inquiry-based science instruction.

To help participants better understand the role of inquiry in their teaching of the module, the program may want to increase the scaffolding for this portion of the training. One possibility would be to first present and discuss the five essential features, without the variations, to help participants develop a common language and vision for inquiry. The variations, which show different ways these features can be incorporated into instruction, could then be introduced. Analyzing activities in the modules for how they incorporate these elements, a task currently in the training, could then serve as an opportunity for participants to apply what they are learning about inquiry to the materials they will use in the classroom. (It is interesting to note that most of the activities in the various modules fall on the “guided” side of the variations chart, but participants may not have recognized that fact.) Communicating a clear and consistent vision of inquiry would avoid confusing teachers and provide them with a concrete image on which to base their science teaching, as well as reducing the likelihood that teachers would see these activities as, in the word of one interviewed teacher, “fluff.”

- *Preparing teachers to implement the module at the mechanical level*

Familiarizing teachers with the structure and activities in the module is a necessary step in moving them along the continuum towards mechanical, and then purposeful, implementation of a module. Based on HRI’s observations, the trainings appeared to be very successful at familiarizing teachers with the materials in the modules they would be using, as well as the mechanics of working through the various investigations. As soon as teachers received the teacher manual for the module, most facilitators gave the teachers an overview of what is in the manual by walking them through the various sections, including the unit overview, background information for teachers, alignment to national standards, and assessment.

The teachers then spent the bulk of the training experiencing the activities in the module as if they were students. Doing so provided them with the operational knowledge of what the

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[11] See page 29 in: National Research Council. (2000). *Inquiry and the national science education standards*. Washington, DC: National Academy Press.

materials looked like and how each investigation was supposed to work. Because the trainings were led by experienced teachers who had previously used these modules, participants received tips on managing the module materials and students throughout the training. Management tips included, for example, showing teachers the proper way to build a circuit with Fahnestock clips, suggesting that teachers have students do the streak test several times with their minerals to get good results, and ideas on how to empathetically discuss the death of insects used in some of the modules with students.

Although most sessions were strong in this area, observation data indicated that there was some variation in quality. The main difference appeared to be due to the extent to which the session provided opportunities for teachers to reflect on how they would implement the module in their classrooms. Common modes of reflection included group discussions about activities from both the student perspective and the teacher perspective; charting facilitation tips; and creating a notebook of facilitation notes that the teachers could refer to during implementation. One observer described a session where notebooking was successfully used:

> During a three-day training on the *Rocks and Minerals* module, participants used their science notebooks to reflect on how to use the materials in the kit. During this session, the facilitators encouraged the participants to use one page to write what the students would have in their notebooks and one page to write notes that they would like to remember as teachers. For example, when the participants were completing the activity where they see if the minerals are reflective, one of the facilitators said, "I hear [the other facilitator] using this question: 'Does this reflect like metal or reflect like glass?' You may want to write that down in your teacher's page."

In other sessions, little time was allowed for participants to reflect on the use of the materials. For example, in some sessions, although participants were encouraged to set up their notebooks with student and teacher pages, they were not given adequate opportunities to step back from the student role and think about the activity from a teacher's perspective.

Overall, familiarizing teachers with the activities in the module, and providing them with practical implementation tips, was a strength of the Initial Module Training sessions. The SIE program may want to consider ways to ensure that all sessions provide both the structure and the time for teachers to reflect on how they can best implement the activities.

- *Deepening teachers' understanding of the content in the module at the student level*

Although teachers can implement a module mechanically with a limited understanding of the relevant science content, purposeful implementation requires teachers to have a solid grasp of the science content in the module. As a start, teachers need to understand what concepts and skills each lesson is intended to teach.

The main strategy used for deepening teachers' understanding of the science content was having them complete the module activities as if they were students. This strategy is commonly used in professional development and makes good use of workshop time as it also serves the goal of familiarizing teachers with the module. To be effective, though, workshops that employ this strategy must also provide opportunities for the participating teachers to "step back" and reflect on the activity, both as a learner of scientific content and as a teacher getting ready to implement the activity in their classroom.

In nearly all of the observed sessions, facilitators began each activity with a "focus question," which, as the name implies, is meant to focus participants on the main ideas of the activity. In the most effective sessions, facilitators had participants re-examine the focus question after completing the activity. For example, in training on the *Human Body* module, prior to engaging with the activity in which they constructed a model of a leg, participants were asked to consider how muscles enable bones to move and record their ideas in their science notebooks. After the activity, participants discussed what they had learned related to this question as a result of the exploration. Facilitators also had participants consider how their initial ideas had changed as the result of the investigation.

In about half of the observed workshops, opportunities for participants to reflect on what they were learning were inconsistent; facilitators had participants reflect on some activities, but not others. For example:

> During an activity on levers from the *Levers and Pulleys* module, participants were focused on answering the question, "What happens to the effort needed to lift a load as the position of the load changes?" Groups tested the effort needed as the load was moved to six different locations on the lever arm. At the end of the activity, participants graphed their results and compared these graphs to ones they completed during an earlier activity in which they moved the fulcrum closer and farther from the effort. The facilitators then engaged the participants in a discussion to help them make sense of the content. However, this focused sense making was observed only for this one activity. Although some of the other activities included reflection questions, they tended to be too vague to ensure that teachers really understood the content (e.g., "What did you learn about pulleys?").

In some cases, participants were able to draw a conclusion from an activity, but were not helped to see the connection between their specific conclusions and the scientific principle targeted by the activity. For example, in an activity from *Environments*, participants did an activity in which they observed whether beetles migrate toward the moist or dry side of a container. However, the connection was never made to the broader scientific idea of "preferred environment." Finally, in a small number of sessions, observers noted that teachers had no opportunities at all to reflect on the content within the modules. In these sessions, the participants were focused solely on the mechanics of the activities.

In addition to variability in the extent of opportunities provided for teachers to reflect on the content, sessions varied in the extent of accuracy of the content being presented to teachers. Many sessions handled the science content well, but others had content issues that ranged from minor to substantial. For example, in a session on the *Ecosystems* module, during a discussion about how oxygen is released during photosynthesis and carbon dioxide during respiration, one facilitator said "plants make much more oxygen during the day than what they use at night." In the context of the discussion, the statement may have given participants the impression that respiration occurs only at night. Although the facilitator clearly knew that respiration occurs constantly, day and night, the "loose language" could well have reinforced a common misconception among the less knowledgeable participants.

Sometimes content issues arose because the examples used to illustrate a concept were more complicated than the participants or the facilitators realized. For example, in a *Chemical Tests* workshop, participants were engaged in a discussion about the differences between solutions and suspensions. Examples of a number of common mixtures, such as a mixture of baking soda and

water, toothpaste, and Jell-O, were introduced to try to help participants understand the distinctions. Unfortunately, these examples are not as straightforward as they appear to be and led to a number of inaccurate statements being made. For example, in discussing the examples the facilitator said, “Toothpaste is a solution unless it’s got globs of that green freshener mixed in it.” and “Jell-O is a solution; add fruit it becomes a suspension.” In actuality, toothpaste and Jell-O are both colloids (a concept that is not covered in the module and consequently was not dealt with in the training). Because these mixtures are ones that students are likely to bring up, this example highlights the importance of teachers developing an understanding of the science content at a deeper level than students are expected to learn. The example highlights the need for facilitators to have deep understanding of the content as well.

In some sessions, facilitators dealt with science content beyond the student level, though they did not always make clear the distinction between content meant for students and content meant for the teaching participants. For example, in a *Magnets and Motors se*ssion, facilitators described how the gauge of a wire is related to its electrical resistance. Later in the session, the facilitators noted that there are three types of metals that are magnetic: iron, nickel, and cobalt. However, in neither case was it made clear to the participants whether or not they should introduce this information in their classroom. Pointing out to participants what content information is for their own benefit and which is appropriate for students would avoid confusion about what content was developmentally appropriate for students.

Although it is not feasible, or desirable given the advantages of spaced learning, to engage participants with all of the science content around a topic in an introductory workshop, it is important that a solid foundation be laid for future trainings to build upon. The program may find it beneficial to create a conceptual map for each topic that includes not only the ideas covered in a module, but also related scientific ideas that are necessary for a more complete understanding of the content and that help tie the module ideas together. Doing so may help facilitators decide when participants need to be introduced to ideas beyond the student level.

In addition, the SIE program may want to consider incorporating a mechanism into the initial module trainings to help participants begin to see the interconnections of the concepts. One possibility would be to have the participants, after completing each module activity, come to a consensus statement about what students are supposed to learn from the activity. At the end of the workshop, the facilitators could show the participants how the ideas fit together from a scientific standpoint. Such activities would help participants begin to see the big picture, and help prepare them to understand the content storyline in the module. In addition, providing this conceptual map to participants would give them something to refer back to while they are teaching the module.

- *Deepen teachers' understanding of the content storyline of the module*

Purposeful implementation of a module requires teachers to have a good grasp of how the targeted science ideas are developed through the activities in the module. Specifically, teachers need to understand both what concepts and skills each lesson is intended to teach and how each lesson contributes to the development of this knowledge. As described previously, a solid understanding of the scientific content (concepts and skills) addressed in the module is a prerequisite for understanding the storyline.

The modules themselves provide some background information for teachers on the content they intend students to learn through the module activities. For example, the STC modules provide an overall introduction to the module, a rough "storyline," (though the STC storylines tend to focus more on what students will *do* than on what students will *learn*) and a brief content overview for teachers before each lesson. Similarly, the FOSS modules provide a unit overview and a teacher background section for each investigation. However, the modules vary in the extent to which they explicitly relate the student activities to this content information. Helping teachers understand the relationships between activities and the concepts targeted in a module is essential in helping them move toward purposeful implementation of a module.

The content storyline element of the professional development was rarely seen in the observed sessions. In most of the observed sessions, facilitators pointed out the section of the module that described the content covered, but few sessions went beyond this step.

If the SIE program decides to introduce a conceptual map to participants at the training, one possibility for getting participants to think about the content storyline would be to engage them with the connections between the conceptual map and the module activities. For example, participants could be split into small groups, with each group asked to trace the development of a different idea through the module. Small groups could then share their findings with the whole group. (It is important to note that this type of activity would likely need to take on a different flavor for the early elementary grade modules, as those focus less on content and more on developing students' process skills.)

However, before engaging participants with this type of task, it will be important for SIE facilitators to develop the conceptual map and storylines themselves. The SIE program may want to have these conceptual maps reviewed by content experts (e.g., Ph.D. scientists in the appropriate field) to ensure they are both accurate and cohesive. In the future, the program could build on these storyline documents, adding information about common student misconceptions and how they can be addressed with the module. In addition to the benefit these documents would have for participating teachers, they would also be of great help in bringing new facilitators up to speed.

- *Preparing teachers to use instructional strategies, specifically notebooking and questioning, that support module implementation*

Teachers need to understand the pedagogical strategies that can be used in implementing a module effectively, as well as when and why to use each of those strategies. Overall, the SIE trainings appear to have provided teachers with many opportunities to learn the instructional strategies they will need to implement the module. Many of the facilitators had experience implementing the modules in their own classrooms, which allowed them to share teaching strategies that they know work. (This aspect of the sessions was greatly appreciated by participants.) In addition, facilitators were often very explicit about what they were doing and why. For example, facilitators stopped frequently and pointed out the different ways they were utilizing science notebooks, an important way to integrate literacy skills into science teaching, so participants could use those notebooking strategies with their students.

Facilitators also did a nice job of sharing questioning strategies with participants. One effective approach used was when the facilitators had participants step out of "learner mode" and into "teacher mode." In these cases, facilitators explicitly pointed out the questions they used and why they were using them. Interestingly, observers rarely noted facilitators highlighting the questions that the modules suggest teachers use. Making explicit why or why not they should use the questions suggested by the module may help participants be more effective with the modules.

Module Enrichment Trainings

In Year Two, Cohort 1 teachers were offered a two-day module enrichment workshop on their initial module. The module enrichment workshops are intended to move teachers further along the continuum from mechanical to purposeful use of the SIE-supported modules by deepening teachers' understanding of the science content and content storyline of the module, and by deepening their pedagogical content knowledge. Specifically, the project's goals for the enrichment workshops were to:

1. Debrief experiences from teaching the module;
2. Uncover and understand the big ideas in the module;
3. Recognize and interpret student thinking and misconceptions (about the targeted content);
4. Understand how the tasks within the module connect and build to the big ideas; and
5. Identify real-world connections to the big ideas.

In the Fall of 2007, the SIE program piloted four module enrichment workshops. HRI observed all four of the pilot module enrichment workshops in the fall of 2007 and 6 of the 38 module enrichment workshops offered in the spring of 2008. About half of Cohort 1 teachers eligible to attend a module enrichment workshop did so. Because many schools were concerned about the amount of time teachers were expected to be out of the classroom, the program decided to make the module enrichment optional this year and will provide opportunities for teachers to attend a module enrichment workshop next year after their second implementation of the module. This section of the report describes the quality of the SIE module enrichment professional development using data from teacher questionnaires, teacher interviews, and HRI's observations.

Teachers' Perceptions of the Quality of the Module Enrichment Trainings

Teachers had somewhat mixed opinions about the SIE module enrichment workshops. At the end of each session a questionnaire was administered that included questions about the quality of the workshop. As can be seen in Table 11, nearly all participants thought that facilitators encouraged active participation (94 percent) and that there were opportunities for teachers to collaborate with peers (93 percent).

Table 11
Teacher Opinions of the Quality of SIE Module Enrichment Professional Development

	Percent Agreeing† (N = 590)
The facilitators encouraged active participation and investigation by all participants	94
There were opportunities for participants to express their views and collaborate with peers	93
The facilitators were well prepared	90
Questions about the science content in the module were adequately addressed by the facilitators	87
Adequate, time, structure, and guidance were provided for participants to discuss the SIE modules and pedagogical strategies with each other	87
Adequate time, structure, and guidance were provided for participants to reflect individually on the substance of the professional development	86
The facilitators shared tips and suggestions for successfully implementing the module	85
The professional development reflected careful planning and organization	85
The facilitators modeled effective teaching strategies	85
The goals of the professional development were clear	81
The professional development increased my understanding of the science content in the module	78
The professional development prepared me to use the teaching strategies promoted by SIE	78
The facilitators explicitly discussed how, when and why to use different teaching strategies	77
The various components of the training were useful in meeting the goals of this professional development	76
The professional development was relevant to my classroom instruction	76
The professional development increased my confidence in my ability to teach using the SIE module	75
The professional development familiarized me with the activities and materials in the module	73
The professional development was worth the time that I invested	65
I would recommend this professional development to a colleague	64

† Includes those teachers agreeing or strongly agreeing with each statement.

However, only about two-thirds of respondents thought the workshop was worth the time invested (65 percent) or that they would recommend the workshop to colleagues (64 percent). Nearly one-third of the attendees thought the pace of the workshop was too slow. (See Table 12.)

Table 12
Teacher Opinions of the Pace of SIE Module Enrichment Trainings

	Percent of Teachers (N = 590)
Much too slow	9
Somewhat too slow	23
Appropriate	67
Somewhat too fast	1
Much too fast	0

Participants were also asked to reflect on which aspects of the workshop they found to be the most valuable. The most frequent responses identified opportunities to improve their content understanding (27 percent) and to collaborate with peers (26 percent) as being particularly beneficial. Interview responses about the most valuable aspects of the workshops frequently focused on the content presented. For example:

Finding out more about [the topic]. I feel more comfortable teaching this to my students.

The content deepening; prior, students would have questions about things [that I] couldn't answer.

[The module enrichment workshop] did help us, quite a bit with the content because, like I said, we were a little bit scattered as to how this was all going to come together…but after we went to the content deepening, we understood a lot more.

Other responses included comments about the high quality of facilitation and teaching strategies gained.

In another open-ended item on the questionnaire, participants were asked to reflect on aspects of the workshop that they thought could be improved upon. Thirty-four percent of the respondents indicated that they did not think the workshop needed any improvement. Of the suggestions for improvement that were offered, the most common suggestion, given by 19 percent of the respondents, was to condense the workshop into a shorter program. No other suggestion was mentioned by more than a few participants.

Although the questionnaire data were quite positive, interviewed teachers expressed more concern about the quality of these workshops. Interviewees indicated a general sense of confusion about the purpose of the module enrichment workshops, indicating they didn't know ahead of time what to expect from the workshop or that the expectations they had were not met. As one teacher said:

We went there thinking it was going to be different than what it was. We went thinking that… they were going to give us more activities, like, for the kids, or more… books, or… other reference sources that we could go to.

Two interviewed teachers indicated that they decided not to attend a module enrichment workshop because of negative feedback from teachers who had attended; a teacher scheduled to attend an enrichment workshop expressed a concern based on colleagues' experiences:

We have had some colleagues that have gone to the enrichment deepening, or the content deepening, and they have come back not real happy…because they said that [it] really was not relevant to classroom use. So, actually, I'm a little…skeptical now, about…going to my content deepening. And I think the content deepening that my colleagues have gone to has been more of a deepening for them, more of an understanding of the module, but it wasn't something that they felt they could actually bring back and use in the classroom.

Clarifying the purposes of the module enrichment workshops for teachers and making sure those purposes are evident in the workshop will be important as the program prepares to offer more of these trainings in the future.

Observers' Perceptions of the Quality of the Module Enrichment Trainings

The analysis of observation data from the module enrichment trainings focuses on the major goals of the sessions.

- *Debriefing experiences from implementing the module in the classroom.*

Most teachers who attended module enrichment workshops had already attended an initial module training and taught the module at least once. Typically, teachers who are implementing a new program have a strong desire to share their initial experiences, so much so that they are often not able to focus on anything else until this desire has been satisfied. Thus, SIE wisely incorporated a session in the spring module enrichment workshops to provide this opportunity to participants. During this session, facilitators posed five questions to participants:

1. What strategies did you use to implement inquiry in the module?
2. How were you able to integrate the use of a notebook in your module instruction?
3. What are some assessment strategies (formative/summative) you have used with the module?
4. What questions concerns and comments do you have regarding management of the modules (i.e., time, classroom, and materials)?
5. What science concepts and content misconceptions did the students present to you?

Participants provided their thoughts, either individually or in small groups, and then engaged in a whole group discussion about each question. Although this portion of the workshop tended to work well, observers noted two areas in which it could be improved. Most of the teachers did not appear to be ready for some of the questions, particularly the ones on assessment strategies and misconceptions. In order to identify what misconceptions students have, teachers need to have both a strong understanding of the content so they know which ideas are correct/incorrect, and an understanding of which incorrect ideas get in the way of student learning. Lacking this knowledge, participants tended to misinterpret the questions. For example, in one session, participants interpreted the question about student misconceptions as "what did students have trouble learning."

The second issue identified in the observations was that too much time was devoted to this segment of the workshop. Several observers noted that participants tended to get off task and start talking about unrelated topics in their small group discussions. In addition, during the large group discussion participants often repeated the points already mentioned by others.

The program may want to consider reducing the number of questions posed to participants, focusing on those that are most salient given their previous experiences, and tightening the schedule to keep the pace appropriate.

- *Understanding the big ideas of the module*

One of the goals of the module enrichment workshops is to help teachers understand the science content in their module at a deeper level. In observed workshops, the science content was addressed in different ways. In some workshops teachers were engaged with hands-on activities; in other sessions participants read articles about the content. Some facilitators presented the content to participants in a lecture format. It was not uncommon for workshops to use a

combination of these approaches. Across the observed sessions, there was variability in the quality of content treatment regardless of the instructional strategies utilized.

In most cases, teachers were engaged with important scientific ideas, evident by their conversations with each other and with facilitators. However, across the observed sessions many teachers still seemed to lack the big picture of the topic; the disciplinary content often came across as isolated bits of information, with not enough emphasis on developing the larger conceptual framework. In cases when a session did address the larger framework, participants sometimes struggled because they did not yet have all the pieces necessary to see the underlying connections among the concepts and how they related to the big ideas. For example, in one workshop the facilitators elected to skip a concept that they thought was not that important to cover. However, later in that workshop, participants had difficulty understanding some of the ideas that were covered because they did not understand the more basic idea that was omitted.

In addition, participants in a number of the observed workshops indicated that they did not understand why they were being asked to learn ideas that they were not expected to teach to their students—they did not see how the broader ideas could help them be more effective in teaching the module to their students. Given that most elementary teachers do not have strong science backgrounds, helping teachers develop a working understanding of the content in their module and the broader knowledge they need to be effective in the classroom may be the most difficult aspect of the program's work. As noted earlier, developing conceptual maps for the science topics related to each module may help teachers see the relationship among the ideas that are addressed directly in the module and those which will help them implement the module more effectively.

- *Understanding how the tasks within the module connect and build to the big ideas (Content Storyline)*

In all observed sessions, the content storyline was addressed with a similar activity. Participants were given a list of statements and asked to categorize them as a "big idea," "learning goal," or "instructional task." Once participants had categorized the statements, they were asked to connect the statements in a hierarchical way to create a "map." Though the activity was similar across all observed sessions, the nature and quality of implementation varied. For example, in some sessions participants were provided with definitions of big idea, learning goal and instructional task; in other sessions participants were asked to come up with the meanings on their own. In one session when participants asked the facilitator for more guidance about what each category meant, the facilitator encouraged them to come up with their own definitions. In sessions where the terms were not defined, observers noted that several participants became frustrated and disengaged from the activity. In other cases, the lack of agreement on the meaning of these terms got in the way of the participants focusing on the intended goal of the activity. In the absence of understanding the meaning of the categories, participants' focus shifted from attending to how key ideas are developed and addressed in the module to developing a definition for each category.

At the end of the activity, facilitators typically presented an answer "key," and participants' maps were usually different than the key. Facilitators told participants that it did not matter how they arranged their statements, as long as they had a good argument to support their reasoning.

Avoiding a definitive “right” answer appeared to generate a great deal of confusion and disagreement among participants about which statements fit into which category. For example, in one session, participants and facilitators had an extensive conversation about how each statement was categorized. Participants ultimately disagreed with the facilitator and could not be won over. This discussion dominated the session and many other participants were having side-bar conversations that were unrelated to the topic. Once the facilitator got everyone back on track, the group that did not agree with how the statements were categorized disengaged from the activity, stating that they just “don’t get it.” One observer noted, “Only a small number of participants contributed; the participants that contributed seemed to have the best understanding of the content.”

Although this activity may have helped participants understand how the ideas in a module connect, it was not apparent that participants always understood how the module developed those ideas. Observers noted that although there were instructional tasks included in the activity, there typically were no explicit links made between the ideas and specific lessons in a module.

- *Recognize and interpret student thinking and misconceptions (Pedagogical Content Knowledge)*

In addition to understanding the science content related to a module, teachers would benefit from knowing what ideas students are likely to have that interfere with their learning, how to assess which ideas (correct and incorrect) their students have, and what strategies they can use to move student thinking forward. This type of knowledge is often referred to as pedagogical content knowledge (PCK), and generally requires an understanding of both the science content and how students learn a particular idea.

The observed module enrichment workshops took different approaches to deepening teachers’ PCK. In some sessions participants examined samples of student work to identify student thinking and misconceptions about the targeted content. In other sessions participants watched videos of student interviews that highlighted student thinking and their misconceptions about the targeted content. Participants were also given publications about formative assessment to read in several sessions.

Overall, this portion of the workshop seemed aimed more at introducing teachers to the idea that students have misconceptions and that there are strategies for assessing student understanding than at preparing teachers to implement these strategies in their classroom. Given that many of the teachers had not previously encountered these ideas, it would not be reasonable to expect much more. Not surprisingly, given the weak content backgrounds of many elementary teachers, some participants struggled with this portion of the workshop. For example, in one session participants had difficulty identifying the misconceptions in samples of student work. The observer noted, “Participants did not understand the science content well enough to fully understand what student thinking was scientifically accurate and what thinking was inaccurate.”

In other cases, participants had issues with the activity because it was too disconnected from the module. For example, in some sessions, the samples of student work they were given to analyze were not from an activity in the module. In another session, participants were able to identify the

misconceptions in the videotaped student interviews, but were unable to come up with strategies on their own to help students let go of those misconceptions.

Although this portion of the workshop successfully introduced teachers to the concept of formative assessment and raised their awareness of misconceptions, preparing them to use this information in their classroom would likely take much more intensive professional development.

IMPACT OF SIE ON TEACHERS AND TEACHING

This section of the report focuses on how the SIE program has impacted teachers, including their preparedness to use their SIE-provided module, and their classroom teaching. Data come from teacher questionnaires and interviews, assessments of teacher content knowledge, and classroom observations during module implementation.

Teacher Preparedness

The post-professional development questionnaire included a series of items aimed at assessing teachers' perceptions of their preparedness to use the teaching strategies promoted by SIE (e.g., how well prepared they felt to use the inquiry-based teaching strategies embedded in the SIE module, use science notebooks to support student learning of the content in the SIE module, and use a learning cycle). To assess impacts, teachers were asked about both their current preparedness and their preparedness prior to the professional development session. This "retrospective pre" approach is useful when respondents are likely to change their perceptions of initial knowledge/preparedness as they learn more about the topic (i.e., they didn't realize how much/little they knew about a topic until after their participation in the program). Cohort 2 teachers were also asked these questions on the end-of-year questionnaire to examine whether use of the module affected teachers' perceptions of preparedness.

Responses to these items were combined into a composite variable (called "perceptions of pedagogical preparedness") to reduce the unreliability associated with individual survey items.[12] Each composite has a minimum possible score of 0 and a maximum possible score of 100. A score of 0 would indicate that a teacher selected the lowest response option for each item in the composite, whereas a score of 100 would indicate that a teacher selected the highest response option for each item.

These longitudinal data have a nested structure, with time points nested within individual teachers. Statistical techniques that do not account for such nested data structures can lead to incorrect estimates of the relationship between independent factors and the outcome. Hierarchical regression modeling[13] is an appropriate technique for analyzing nested data and was used to examine trends in teachers' composite scores.

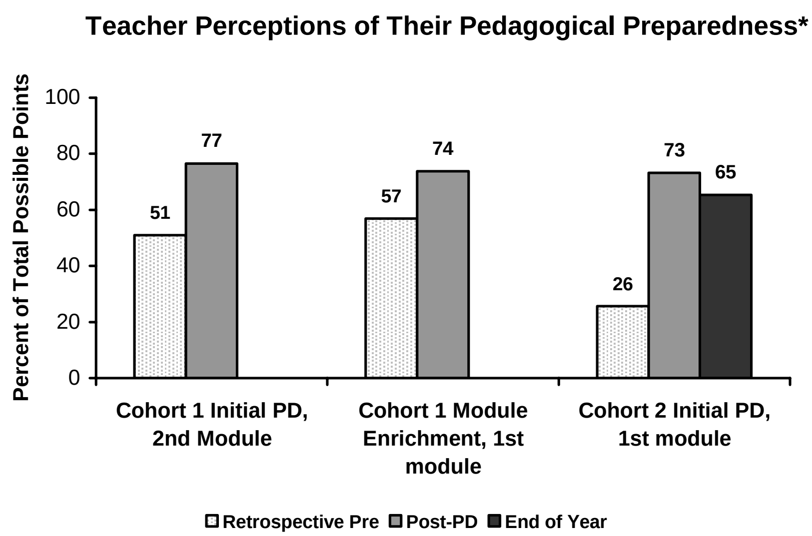
As can be seen in Figure 5, teachers' perceptions of their pedagogical preparedness increased dramatically as a result of the professional development. Composite scores for Cohort 1 teachers increased from a mean of 51 to a mean of 77 as a result of the initial training on their second

[12] Definitions of this and other composites described in this report, a description of how the composites were created, and reliability information are included in Appendix C.

[13] Bryk, A.S. & Raudenbush, S.W. (1992). *Hierarchical linear models: Applications and data analysis methods.* Newbury Park, CA: Sage Publications.

module (a large effect[14] of 1.16 standard deviations). Similarly, scores of teachers who attended the module enrichment trainings changed from a mean of 57 to a mean of 74 (an effect of 0.77 standard deviations). Cohort 2 teachers' scores were similar to Cohort 1 teachers' scores in Year One, increasing from 26 points to 73 points as a result of the initial module training (a very large effect of 2.18 standard deviations).

It is interesting to note that Cohort 1 teachers' two retrospective pre scores are similar, and that their perceptions of preparedness prior to the module enrichment workshop did not reflect the gains from the initial training on their second module (which most of the teachers had attended several months before the module enrichment sessions). This result may be due to the teachers answering the questions with respect to two different modules. The apparent difference in retrospective pre scores between the two cohorts is likely due to Cohort 1 teachers having participated in training last year.



* Teacher scores changed significantly over time, $p < 0.05$ (HLM)

Figure 5

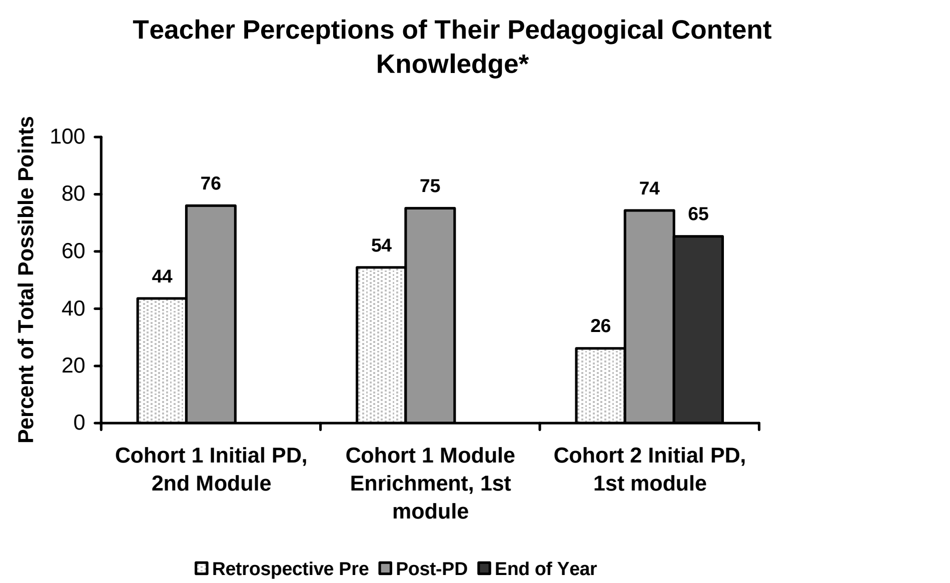
The slight, but significant, decrease at the end of the school year for Cohort 2 teachers may be due to a wearing off of a "halo effect" (i.e., teachers who enjoy a professional development session may overestimate the impacts of that session when asked immediately following it). The dip may also be due to teachers having the experience of trying these strategies in the classroom, and realizing they weren't quite as well prepared as they thought they were. Still, the overall trend is positive with large increases for both cohorts, an indication that the professional

[14] The effect size for the comparison of two adjusted means is calculated as the difference between the means divided by the pooled standard deviation. Effect sizes of about 0.2 are typically considered small, 0.5 medium, and 0.8 large. Cohen, J. (1988). *Statistical power analysis for the behavioral sciences.* Hillsdale, NJ: Lawrence Erlbaum Associates.

development increased teachers' feelings of preparedness to implement the modules in their classrooms.

The questionnaires also asked teachers to rate their understanding of the science content in their module. Items asked about their understanding of (a) the student learning goals in the SIE module; (b) the science content in the SIE module at a deeper level than what students are expected to learn; and (c) ideas (either correct or incorrect) that students are likely to have about the content prior to instruction. These items were also combined into a composite, in this case titled "perceptions of pedagogical content knowledge."

The results for this composite parallel those for the perceptions of pedagogical preparedness composite, likely for the same reasons. (See Figure 6.) The increases for Cohort 1 teachers correspond to large effects of 1.46 and 0.93 standard deviations for the initial and module enrichment trainings, respectively. The 28-point increase for Cohort 2 teachers corresponds to a very large effect of 2.18 standard deviations. As with the perceptions of pedagogical preparedness composite, there was a small, significant decrease from just after the professional development to the end of the school year for Cohort 2 teachers.



* Teacher scores changed significantly over time, $p < 0.05$ (HLM)

Figure 6

In interviews, teachers indicated that the professional development helped them understand the content in their module. For example:

> *It did help us, quite a bit with the content because, we were a little bit scattered as to how this was all going to come together, but after we went to the content deepening, we*

understood a lot more. And, we understand the actual skills and concepts that they need to know when they go on to 3rd grade.

In spring 2008, HRI conducted a pilot study of the impact of SIE's "Module Enrichment" workshops on teacher science content knowledge. This pilot study focused on four SIE-supported modules: *Electric Circuits, Levers and Pulleys, Mixtures and Solutions,* and Motion *and Design*. HRI developed a short (15 items) teacher assessment for each of these modules. The assessment items were reviewed both by the Pennsylvania Department of Education and by external science content experts.

Cronbach's Coefficient Alpha was calculated to examine the extent to which the items on each assessment appeared to be measuring the same construct; items that did not correlate well with the overall scale were dropped from the analysis. Table 13 shows the reliability for each group of items for the modules that were assessed.[15] Three of the 4 assessments had acceptable reliabilities. The reliability for the Motion and Design assessment was fairly low; thus, results from this assessment should be interpreted with caution.

Table 13
Teacher Assessment Item Reliability

	Number of Items	Reliability
Electric Circuits	12	0.61
Levers and Pulleys	14	0.78
Mixtures and Solutions	15	0.71
Motion and Design	13	0.56

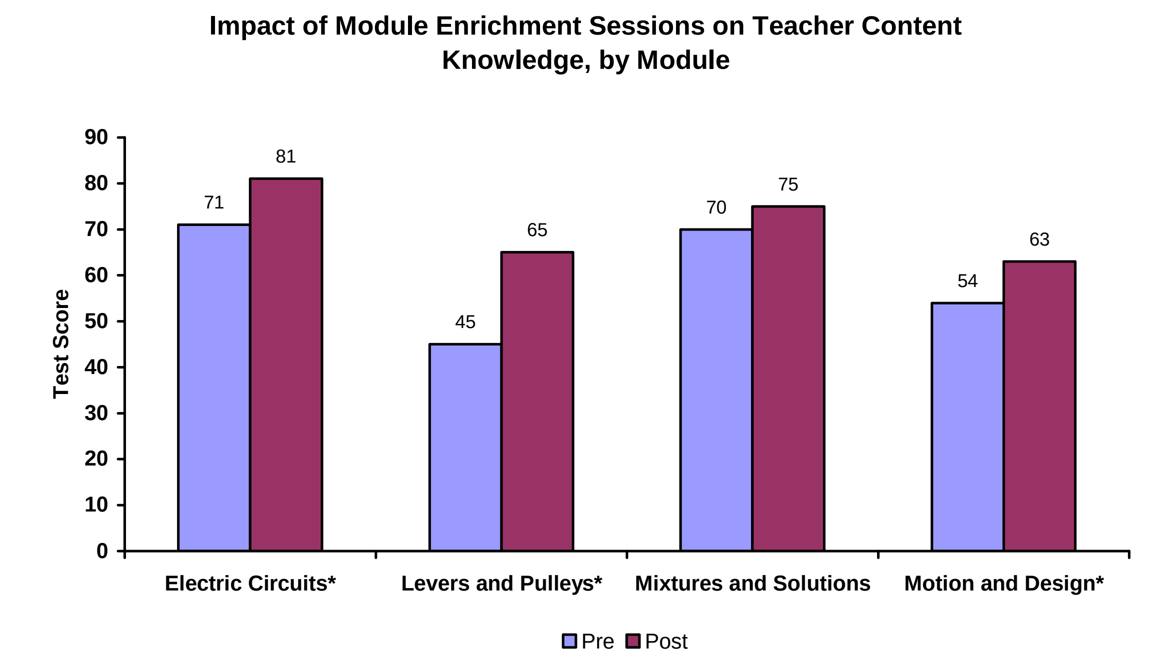
The assessments were administered at the beginning and the end of the two-day module enrichment workshops on these modules. HRI received pre- and post-test responses from 124 teachers across the four modules; however, 22 teachers did not indicate the topic of the workshop, reducing the number of valid assessments to 102. Table 14 shows the number of valid responses for each module. It should be noted that the sample size for Mixtures and Solutions is very small, making it very unlikely a statistical test would detect a change from pre- to post-test, even if one truly existed.

Table 14
Sample Sizes for the Teacher Assessments

Module	Number of Valid Pre/Post Responses
Electric Circuits	38
Levers and Pulleys	25
Mixtures and Solutions	11
Motion and Design	28

[15] A Cronbach's Alpha of 0.6 is considered acceptable, 0.7 fair, 0.8 good, and 0.9 excellent.

Figure 7 shows the average pre- and post-test score for each module. Post-test scores were significantly higher in 3 of the 4 workshops: *Electric Circuits*, *Levers and Pulleys*, and *Motion and Design*. Although the trend is in the expected direction for Mixtures and Solutions, the difference was not statistically significant (again, likely due to the very small sample size).



* Post-test score significantly higher than pre-test score (one-tailed dependent samples t-test, $p < 0.05$).

Figure 7

The 10-point increase in scores for *Electric Circuits* corresponds to a medium effect size of 0.60 standard deviations; the 20-point increase for *Levers and Pulleys* corresponds to a large effect of 0.96 standard deviations; and the 9-point increase for Motion and Design is equivalent to a medium effect size of 0.59 standard deviations.

HRI examined the assessment results in more detail to determine which ideas teachers seemed to be getting and which they still struggled with after the module enrichment workshops. On the *Electric Circuits* assessment, teachers appeared to have consistent gains on understanding what is and isn't a complete circuit, and the relative brightness of bulbs in simple (i.e., single bulb and battery) and parallel circuits. Teachers also seemed to gain an understanding of how electric current flows in simple and series circuits, but did not seem to understand current flow in parallel circuits.

Teachers in the *Levers and Pulleys* module enrichment sessions appeared to gain a better understanding of the definition of "effort," identifying the different classes of levers, and comparing the mechanical advantage between lever and pulley systems. Teachers seemed to struggle with the concept of work and how it applies to levers and pulleys.

Teachers in the *Mixtures and Solutions* sessions appear to have increased their understanding of the similarities and differences of mixtures or solutions. However, many teachers did not appear to understand what a chemical reaction is or that chemical reactions always result in new substances being formed.

Teachers in the *Motion and Design* module enrichment sessions showed gains on the items related to kinetic and potential energy, and how energy is transferred. Teachers also seemed to gain a better understanding of Newton's First Law (i.e., that the motion of an object will not change unless an unbalanced force acts on it). However, a substantial number of teachers still had difficulty letting go of the incorrect ideas that a forward force is needed to keep an object in constant motion, and that a moving object has a force in it that keeps it moving. Participants also seemed to struggle with the concept of friction and the direction in which it acts. A fair number of teachers also continued to have difficulty with the distinction between acceleration and speed, and consequently Newton's Second Law (i.e., the acceleration of an object depends on both its mass and the net force applied to it).

Module Implementation

In its first year, SIE offered support for 11 different modules to Cohort 1 schools. In grades K–2, SIE offered one module at each grade. In each grade 3–6, SIE allowed schools to select one of two modules. In Year Two, SIE introduced a second set of 11 modules, including one at each grade K–2, and two at each grade 3–6. Cohort 1 schools were expected to implement a second module at each grade, and were allowed to select their new modules from among the 22 modules being supported by SIE. Cohort 2 schools were expected to implement one module at each grade, and were allowed to select from the initial set offered by SIE.

Both teachers and principals were asked on questionnaires about factors that may have affected, positively or negatively, teachers' use of the module. Results from these questions are shown in Table 15 and Table 16. Nearly all of the responding teachers and principals thought that the SIE professional development facilitated use of the module, and that teachers supported each other in the use of the module. Most respondents also indicated that the SOS facilitated use of the module. In addition, although the SIE program does not have any formal mechanisms for assisting teachers outside of the workshops, roughly one-quarter of the teachers and more than half of principals indicated that teachers received extra assistance that helped them implement their module.

Table 15
Teacher Opinions of Factors Affecting Their Use of the SIE-Provided Module

	Percent of Teachers Agreeing† (N = 1,768)
Factors Facilitating Use	
The training I received from SIE made it easier for me to use the modules.	95
Other teachers in my school provided a support system for use of the modules.	86
My own science background was helpful when I was teaching from the modules.	77
My SOS facilitated my use of the modules.	73
I received assistance from SIE outside of the workshop that helped me to use the modules.	26
Factors Inhibiting Use	
The amount of time required to prepare for instruction with the SIE modules was problematic.	55
There was not enough instructional time for science to effectively use the SIE modules.	52
The pressures to teach mathematics and/or reading inhibited my use of the modules.	51
I am not able to cover all of the science topics I am suppose to because of the time it took to implement an SIE modules.	43
I did not have the modules for long enough to use as much of them as I wanted to.	29
The amount of time I was required to be out of the classroom was problematic.	26
My lack of experience in science made it more difficult for me to teach from the modules.	15

† Includes those teachers agreeing or strongly agreeing with each statement.

Table 16
Principal Opinions of Factors Affecting Teacher Implementation of the SIE-Provided Modules

	Percent of Principals Agreeing†		
	Overall (N = 93)	Cohort 1 (N = 48)	Cohort 2 (N = 45)
Factors Facilitating Use			
The training teachers received from SIE made it easier for them to use the modules	99	98	100
Teachers provided each other with a support system for using the modules	98	96	100
Our Support on Site (SOS) facilitated teachers' use of the modules	85	83	87
Teachers received assistance from SIE outside of the workshop that helped them to use the modules	61	67	56
Factors Inhibiting Use			
The amount of time teachers were required to be out of the classroom was problematic	57	56	57
The pressures to teach mathematics and/or reading inhibited teachers' use of the modules	38	38	38
Teachers were not able to cover all of the science topics they were supposed to because of the time it took to implement an SIE module	30	33	27
There was not enough science instructional time for teachers to complete the SIE modules	26	27	24
The amount of time required to prepare for instruction with the SIE modules was problematic for teachers	23	23	22
Teachers did not have the modules for enough time to complete all of the lessons	19	19	20
Teachers' lack of experience in science made it more difficult for them to teach from the modules	12	10	16
Teachers' lack of science content knowledge made it more difficult for them to teach from the modules	12	8	13

† Includes those principals agreeing or strongly agreeing with each statement.

In terms of factors that inhibited use of the module, time was a concern of both teachers and principals. Principals were mainly concerned with the time that teachers were out of the classroom to attend professional development. In contrast, highlighted as problematic the amount of time required to prepare for instruction with a module; the lack of instructional time to use the modules effectively; and the pressure to teach mathematics and/or reading. These sentiments were echoed in teachers' responses to an open-ended item that asked participants what aspects of the SIE program could have been improved. Comments included:

> *I did not have enough prep time to prepare for instruction using the modules.*
>
> *Time was an issue for us…The other teachers [also] said how much time it took. There were actually some days, we would not do [the module]; we would kind of double up, maybe an hour another day. You know, once you get that stuff passed out, it takes a lot of time to, read, collect everything and, time was an issue...We had to work off best we could.*

As part of the student achievement study (described more fully later in this report),[16] teachers complete a "module use" survey that asked them to indicate which lessons from the module they used in their teaching, how much instructional time was devoted to the module, and the extent to which they supplemented the module with other instructional materials. As part of the student achievement study, HRI examined how module use changed from Cohort 1 teachers' first implementation in Spring 2007 to their second implementation in Fall 2007. Although the sample size is too small to statistically examine whether extent of module use differs between first and second implementation, a descriptive analysis of the data (see Table 17) reveals that on average, teachers using 4 of the 6 modules (*Levers and Pulleys, Motion and Design, Mixtures and Solutions,* and *Variables*) devoted much more instructional time to the module during their second implementation than during their first implementation. Interestingly, the change in instructional time varies considerably by module, with those aimed primarily at 5th and 6th grade having the largest increases. The percent of the module covered does not appear to have changed from first to second implementation in most cases.

[16] The student achievement study focused on 6 of the 11 modules provided by SIE in Year Two as described later in this report. Data from the Year Two Fall assessment administration were available for this report; data from the Spring assessment administration will be reported in an addendum report.

Table 17
Descriptive Statistics for Instructional Variables, by Teacher Experience with the Module

	Percent of Lessons Covered		Instructional Time on Topic in minutes		Percent of Instructional Time Based on Module	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Electric Circuits						
First Time	86.37	16.69	771.43	285.23	92.86	18.05
Second Time	89.09	12.60	786.40	307.11	97.56	4.90
Levers and Pulleys						
First Time	71.49	26.19	590.22	451.29	93.69	11.23
Second Time	85.03	13.87	1,107.91	539.33	94.64	10.09
Mixtures and Solutions						
First Time	75.13	21.38	842.44	365.12	93.62	18.29
Second Time	86.10	13.76	1,119.94	530.60	85.94	21.14
Motion and Design						
First Time	83.21	23.49	641.90	277.38	86.20	25.13
Second Time	83.11	22.92	961.42	528.06	94.44	13.70
Rocks and Minerals						
First Time	89.14	20.13	818.42	261.02	94.10	10.11
Second Time	86.49	23.56	710.56	285.40	91.09	20.31
Variables						
First Time	86.33	15.82	807.69	304.43	99.29	2.75
Second Time	84.36	25.96	1,228.57	753.25	95.00	7.56

The increase in the amount of time teachers spent on the modules may be due, in part, simply to the fact they received the modules in Year Two in the Fall. The PSSAs are administered in the Spring, reducing the amount of instructional time teachers have to implement the module (both because of the days for administering the assessments and the days schools spend preparing students for the tests). In addition, as a result of their experiences in Year One, some schools have built more time for science into their schedules. As one teacher stated in an interview when asked what led to changes in implementation from Year One to Year Two:

> *We had more time…since last year was our new year with the science program, we did not have set times for [science], so this year, we definitely budgeted in that time. We said, "This is when we're doing science, and that's it."*

In interviews, teachers from both cohorts were asked to reflect on how their teaching changed since their school's involvement with SIE began. The overarching sentiment was that teachers are both teaching more science and using more hands-on activities to do so. Moreover, many teachers indicated that science has taken on a greater a priority at their schools. The following responses were typical:

> *Well, we didn't teach any science [before SIE]. So, we went from nothing to something. So, I guess it drastically changed.*

> *Before, I would say we taught anywhere from fifteen minutes to thirty minutes a day, maybe two times a week, and then once we did the [module] we devoted about an hour a day, two to three times a week with the program.*

[My instruction] has changed. It has become more hands-on. Before we would complain that we thought that our science was basically worksheets and that was it. And now, from learning SIE's hands-on approach, we are able to use that with other themes that we do in our science program.

The module use survey also asked teachers about the extent to which they used the readings[17] and extension activities that came with the modules. As can be seen in Table 18, there was a great deal of variability in the use of these supplemental materials. Given that a number of the readings contain important concepts that are not covered elsewhere in the modules, and the push to integrate science and literacy, it is surprising that the readings are not being utilized more. The program may want to consider ways to emphasize the importance of the readings to teachers in the professional development.

Table 18
Use of Supplemental Module Materials

	Percent of Classes
Readings (N = 386)	
None	4
About one-quarter	21
About one-half	22
About three-quarters	18
All/nearly all	35
Extension Activities (N = 499)	
None	31
A few	47
Many	15
All/nearly all	7

Student Opportunity to Learn

To gain insight into how the modules and the associated professional development were being translated into classrooms, members of the evaluation team observed a sample of 48 participants teaching a lesson from a module. The classroom observations focused on the quality of the instruction in terms of opportunity for students to deepen their understanding of the intended content. Interviews after the observations were used to gather information on the teachers' experiences with the module and SIE professional development.

Sixteen Cohort 1 teachers were observed in the Fall of 2007 teaching their first SIE module for a second time. HRI selected eight schools for the Fall observations; three of these had been visited in Year One and five were randomly selected for Year Two. Two teachers were selected for observation within each school. Observations were also conducted in the Spring of 2008: 16 Cohort 1 teachers implementing their second SIE module for the first time, and 16 Cohort 2 teachers using a module for the first time. Schools and teachers were randomly selected for

[17] If applicable; some modules did not include readings.

these observations. For all three sets of observations, the evaluation focused on modules that were also part of the student achievement study described later in this report.

The framework HRI used for assessing student opportunity to learn is based on research on how people learn. The framework specifies that learning is facilitated by a supportive classroom climate that encourages active participation of all students. Research also suggests that science instruction is most effective when instructional activities are well-aligned with the learning goal, engage students intellectually (i.e., "minds-on" rather than just "hands-on") with important and accurate content at an appropriate level of difficulty, reflect the nature of science (e.g., requiring conclusions to be supported by data/evidence), and help students make sense of the important ideas. Following is an analysis of the observed lessons on each element of this framework, as well as an analysis of factors that may have affected student opportunity to learn.

Extent To Which the Classroom Culture/Learning Environment Facilitated Student Opportunity To Learn

A classroom culture that is respectful of students, encourages students to participate and share ideas, and maintains high expectations for all students aids student learning. The vast majority of the observed lessons had supportive learning environments characterized by a collegial atmosphere that encouraged student participation. For example, an observer reported:

> In a 6th grade lesson from the *Experiments with Plants* module, students worked cooperatively to determine what variable they were going to test, and what their research question would be, in planning a germination experiment. The classroom environment established by the teacher was warm and supportive. It was evident that students felt comfortable sharing their ideas and discussing their thoughts from the large number of students who participated in the class discussions. Students enthusiastically answered questions from the teacher and were eager to share their ideas. For example, during one class exchange, students readily offered their ideas as to which factors they could test in the experiment they were designing.

In a handful of the observed lessons, classroom management issues detracted from the classroom culture. For example, in one observed lesson, while the teacher worked with an individual student the remaining students were off-task and disruptive; one student used the materials for the experiment to drum on the table and another student was shooting blocks into a bucket. Because the teacher had difficulty managing the learning environment, very little progress was made on the lesson goals

In a few other lessons, observers noted that the teacher seemed to favor some students which resulted in different opportunities to learn for different students. For example, during the large group discussion at the end of a *Levers and Pulleys* lesson, the teacher called on the same subset of students to come to the board and answer questions. Students that were not included in the discussion tended to disengage from the lesson.

Although it is beyond the scope of the SIE program to teach basic classroom management skills, the program may want to consider options to provide extra assistance to teachers who struggle with managing a hands-on learning environment.

Extent To Which the Disciplinary Content Experienced by Students Was Accurate

Observers examined the accuracy of the disciplinary content students experienced, including the content presented by the teacher, and the conclusions drawn from data/evidence. Of the 48

observed lessons, 41 had a learning goal related to science content (7 lessons focused solely on process skills), and the science content was accurate in the majority of these. However, there were content errors present in a number of the lessons. Some of the inaccuracies were relatively minor in nature.

However, in eight of the observed lessons the content errors were quite problematic. Sometimes, the teacher introduced inaccurate information to students. For example, in a *Rocks and Minerals lesson*, students were learning about the different types of crystalline structures of minerals (i.e., the regular internal geometric pattern present in most minerals regardless of their outward shape). Although the teacher accurately defined fracture (the shape and texture of the surface formed when a mineral is broken) and cleavage (a fracture in which the mineral breaks along flat planes) to the class, she provided inaccurate information in examples supplementing the lesson. The teacher indicated that the fracture of minerals was similar to what occurred when a human bone was broken: "Think of a bone fracture. It isn't a straight line but jagged. A fracture does not break in a particular shape." In fact, the pattern of fracture is one of the features used to identify the type of mineral. The use of this analogy, although an attempt to relate an abstract science concept to something students were familiar with, likely interfered with students' understanding the concepts in the lesson.

In other cases, the teacher omitted important information and as a result may have led to a misconception. For example in a 6th grade lesson from *Experiments with Plants*, the teacher presented and elicited partially inaccurate information about the life cycle of a flowering plant. The teacher had students call out the steps of the life cycle and drew them on the chalkboard. The students omitted one of the steps and the teacher did not correct them or fill in the step. In addition, the teacher did not make the distinction that the life cycle they were discussing was only for flowering plants and did not apply to all plants.

Extent To Which the Nature of Science Was Accurately Portrayed

Understanding the nature of science as a discipline is an important aspect of learning about science. Students should understand that scientific knowledge is based upon the drawing of conclusions on data/evidence and is not just the memorization of facts. Of course, in order for students to draw conclusions from data they collect, the data must be collected carefully and systematically. Thus, observers also examined lessons for how scientific knowledge was portrayed and whether data collection would facilitate the drawing of appropriate conclusions.

In 28 of the 48 observed lessons, variables were controlled during experimentation and data were recorded carefully. For example:

> In a lesson from the *Environments* module, 5th grade students investigated how their animals (pill bugs and darkling beetles) responded to moisture. After reviewing what living and non-living environmental factors are, the teacher demonstrated the experimental design for the lesson and emphasized the importance of keeping all but one variable (in this case the moisture of the soil) the same. Working in groups, students conducted the investigation by placing one cup of dry soil, one cup of moist soil, and one cup of wet soil in separate piles in the animal runways the students had previously made. Students carefully measured the cups of soil to ensure they were equal and made sure they didn't touch. Students then recorded their experimental setup in their science notebooks. After placing their animals in the runway, students wrote down their observations of the animals for the next few minutes, then again at the end of the period. They would make a final observation of their animals the following day.

In contrast, students were either not controlling variables or not making careful measurements in 20 of the observed lessons. In some cases, the teacher appeared unaware of the consequences of poor data collection. In a lesson from *Mixtures and Solutions*, the students were supposed to learn the concept of solubility, including that solubility varies depending on the materials. Although the teacher stressed the importance of keeping accurate records of their experimental procedure, when students made data collection errors, the teacher was not concerned. As the observer described:

> Several groups were not careful in handling the experimental solution and spilled some of their solution. Neither the students nor the teacher seemed to recognize that this was a potential source of error in the experiment. After observing one group's spill, the teacher told the students, "Don't worry about it and just keep going." At no point did the teacher revisit this situation and indicate how it may have affected the results.

Finally, observers noted in many of the lessons that a lot of data collection occurred, but very little drawing of conclusions from that data was present. Although careful data collection is a pre-requisite step, the critical component of drawing and critiquing conclusions based upon those data was absent in many of the lessons.

Extent To Which All Students Were Intellectually Engaged with the Targeted Ideas in the Lesson

High quality science lessons engage students intellectually with the targeted science ideas. In assessing this aspect of instruction, observers examined the extent to which students were thinking and talking about the intended science content.

Observers found evidence of intellectual engagement in 34 of the 48 lessons. In 20 of these lessons, the observers indicated that students were highly focused on the lesson objectives. Typically, these lessons were both structured and facilitated in ways that fostered intellectual engagement. For example, both the requirements of the activity and the teacher's questions engaged 3rd graders in a lesson from the *Rocks and Minerals* module:

> In small groups, students were actively engaged in using their senses to make observations of rock samples. Students were also recording their observations in their science notebooks. The following exchanges are typical examples of how the students described the properties of their rocks.
>
> Student 1: It's bumpy. All of it's bumpy.
> Student 2: It's shiny, with black stripes.
> Student 3: There is no sound, but it feels rough.
> Student 4: It's shiny.
>
> Further, the teacher's questions helped focus students on identifying distinguishing features of the rock samples:
>
> Teacher: You can't just say something smells horrible…What does it smell like?
> Student 1: It smells nasty, like trash.
> Teacher: How about the weight of the rock? (She models feeling the weight of the rock by gently tossing it and letting it fall into her hand, which the students in several groups watched and proceeded to do themselves.)

> The teacher's questions focused students on making detailed descriptions, which at the end of the lesson helped them to make sense of what a "property" is.

In 14 lessons, the observers indicated that the level of intellectual engagement was mixed. In some cases, students were focused on the intended content during parts of the lesson, but not throughout. In other cases, students were focused on only a subset of the intended goals. For example:

> In a lesson from the *Ecosystems* module, students were intended to deepen their understanding of what an ecosystem is by comparing and contrasting aquatic and terrestrial ecosystems. Students made observations of their terrariums and aquariums with hand lenses, and recorded their observations in their science notebooks. The class also engaged in a discussion about the plants and animals they observed, recording similarities and differences on a large Venn diagram in the front of the room. However, the lesson never had students think about how these examples related to ecosystems.

In the remaining 14 observed lessons, students were not focused at all on the intended content, often because students were concentrating on the process of completing an activity rather than the science content. For example:

> Students in a 3rd grade class working in the *Chemical Tests* module were adding water to five unknown substances to learn that some substances dissolve in water and others do not. This lesson was implemented in a hands-on manner, but was not minds-on for the students. During the activity, student conversations focused on what numbers to record, but not what the numbers meant; many students did not appear to understand what they were doing and why they were doing it. In addition, the teacher's questions during the whole class discussion focused on the procedure of the activity and not what students were finding.

Extent To Which Students Were Given the Opportunity To "Make-Sense" of the Targeted Ideas

The framework used to examine the sample lessons asserts that high-quality instruction involves the teacher and/or instructional materials helping students make meaningful and relevant connections between their experiences and key science concepts (i.e., "making-sense" of the targeted ideas).

Twenty-seven of the observed lessons contained elements of sense-making, though only 12 were judged to have adequate opportunities for students to make sense of the targeted science concepts. The common element in lessons with sense-making activities was the teacher helping students make connections between the instructional activities and science concepts, typically through a whole class discussion at the end of the lesson. For example, in a 6th grade lesson from the *Environments* module:

> The focus of the lesson was for students to learn that carbon dioxide produced by aquatic organisms increases the acidity of the water. During the lesson, students set up an investigation with three cups, each containing 100mL of water. In Cup 1 students added a fish; in Cup 2 they added a sprig of Elodea (aquatic plant); nothing was added to Cup 3. Six drops of the acid indicator bromothymol blue (BTB) were added to each cup. The teacher led a group discussion to help students make the connection between the activity the targeted concept. The discussion included:
>
> Teacher: Okay, why do you think the fish water is turning yellow? Why does it have acid in it?
> Student 1: Oil on (the fish's) body.
> Student 2: Fish went to the bathroom.
> Teacher: It didn't go that much (laughing).

Student 3: Exhaling CO_2?
Teacher: We are going to test that theory. Blow into the water with this straw. [Student blows into the cup with plain water and BTB.] Stop, what color is your water?
Student 3: It turned yellow!
Teacher: Why?
Class: CO_2!
Teacher: When CO_2 and water combine they form an acid called carbonic acid. So, what is BTB testing for?
Student 4: Chemicals in water.
Teacher: Something specific…
Student 1: Acid in the water.
Teacher: If there is acid in the water, what color will the BTB turn?
Class: Yellow.

Fifteen lessons had some, but rather limited opportunities for students to make sense of the science ideas and 16 lessons provided little, if any, opportunity for students to make sense of the targeted ideas. In these lessons, there tended to be no structured time for students to make sense of the targeted ideas. Sometimes the teacher focused the wrap-up discussion on the process of the activity instead of interpreting the data. In other cases, the teacher accepted the conclusion of a single student even though the supporting evidence was incorrect:

> In a *Levers and Pulleys* lesson, 5th grade students were examining what happened to the effort required to lift a load when the effort force is moved farther and farther from the fulcrum in a lever system. The students were shown two lever systems and asked to predict which lever would make the load easier to lift and explain why. The lever systems were the same except that one had the effort force farther from the fulcrum than the other. Students then tested their predictions and the teacher asked the class what they found. One student gave the correct answer, but indicated that the reason was that the fulcrum was closer to the load. The teacher agreed and told the rest of the class to write the "correct" answer in their notebooks.

In five of the observed lessons, although no sense-making occurred, the teacher indicated in the post-observation interview that the class would discuss their data the next day.

Fidelity of Implementation

Twenty of the observed lessons were implemented with a high degree of fidelity. Of these, 15 provided a great deal of opportunity for students to learn the targeted ideas; 5 lessons were implemented with fidelity but judged not to provide sufficient opportunity to learn, reflecting gaps in the instructional materials. For example, a lesson from the *Motion and Design* module has students investigating the relationship between the force applied to their vehicle and the vehicle's motion. Students change the number of washers on the end of a string attached to a vehicle, hanging the washers over the edge of the table, which applies a forward force on the vehicle. The activity asked students to make observations about the speed of the vehicle in each trial. As the vehicle started each trial from rest, the final speed of the vehicle was greater when more washers were added to the string because the vehicle undergoes greater acceleration. However, this connection between final speed and acceleration is not made explicit in the module. In a 4th grade class observed implementing this activity, the observer noted that the teacher did not help students make the connection between the data they were collecting and the targeted science concept even though the teacher had followed the lesson exactly as it was described in the teacher's manual.

Teachers made substantive modifications in the other 28 observed lessons. In these cases, observers indicated that the modifications reduced student opportunity to learn. Interestingly, lessons intended to focus on disciplinary content were more likely be modified by the teachers than lessons that focused on teaching process skills. The most common change was the omission of the wrap-up discussion and associated questions outlined in the instructional materials, reducing the sense-making opportunities in the lessons. For example, in a lesson from the *Human Body* module, students examined animal skeletons found in owl pellets and compared the skeleton of a rodent to the skeleton of a human. The intended goal of the lesson was for students to see that bones that serve similar functions have similar shapes. During the lesson, the teacher has students find the bones in the owl pellets and reconstruct a rodent skeleton as directed in the module. However, the teacher cut out the portions of the activity that asked students to compare the rodent skeleton to the human skeleton and consider the relationship between bone shape and function.

Another type of modification that reduced the emphasis on the science content was more subtle. Some lessons that included investigations in which students were collecting data that could be used to develop a science concept were implemented in a way that focused students on the data collection process rather than making meaning from the data. For example, an observed *Electric Circuits* lesson was intended to teach students that electric current can produce light, heat, and magnetism as evidence for energy being transformed. During the lesson, the teacher focused students solely on properly following the procedures. In fact, the teacher graded students on setting up the experiment properly, regardless of whether or not they collected meaningful data. The idea that electric energy can be converted into other forms of energy was never brought forth in the lesson.

Overall Extent To Which the Lessons Provided Students with an Opportunity To Learn the Targeted Ideas

All of the observed lessons included some elements of effective practice, though only a few lessons managed to "put it all together." Common strengths of the lessons included involvement of students with key content as well as collegial interactions among students and respectful contact between the students and the teacher. Common areas of weakness included the extent of student intellectual engagement with, and sense-making of, the content. Students engaged in many hands-on activities, but the amount of intellectual rigor required of the students in most lessons was generally low. No major differences were found between lessons implemented by Cohort 1 and Cohort 2 teachers; as most of the observations of Cohort 1 teachers occurred prior to the module enrichment sessions, these data indicate that simply teaching a module for a second time is unlikely to have a major impact on the quality of implementation.

Relationship Between SIE Professional Development and Teachers' Perceptions of Preparedness To Implement the Module

Teachers' confidence with the content in the modules and familiarity with the instructional materials can have a great impact on the quality of implementation. Teachers were asked about each of these areas during interviews following the observed lessons.

Thirty-seven of the 48 observed teachers indicated they were comfortable with the content in the module; most attributed this comfort to the SIE professional development though some indicated

that they were comfortable with the content even before participating in SIE. The remaining 11 teachers indicated feeling uncomfortable with the content in their module. As a few said:

> *[The SIE professional development] didn't do much for me. At first, I was a little overwhelmed with it, but I took a lot of time on my own to explore and to understand it online a little bit, but mostly from the teacher manual.*

> *We went over every lesson, and we got to do what the children do. But that didn't really help me learn the science. I could have used a little more background knowledge on the concepts. It was a little new at first.*

Nearly all of the observed teachers felt very confident to use the module in the classroom. Most attributed this confidence to the SIE professional development, saying that going through the activities in the training was very helpful. In the words of a few teachers:

> *Going through it like the kids would, helped me see what to expect.*

> *[The training] gave me ideas on how to go about teaching, you know what kind of strategies to use with them and it really worked.*

> *The training was wonderful. We had a woman that had actually taught the module herself and she gave us tips on what actually worked practically in the classroom verses maybe what the book says to do.*

Overall, most of the observed teachers indicated being well prepared to implement the module, both in terms of familiarity with the instructional activities and the science content. However, teacher perceptions do not appear to correlate with the quality of the observed lessons, indicating that teachers may not yet have a strong vision of high quality science instruction or how to use the module to enact that vision.

IMPACT OF SIE ON STUDENTS

As part of the evaluation of the SIE program, HRI, with the assistance of the PDE, designed and implemented a study to examine the impact of SIE professional development and teachers' implementation of the science modules on student achievement in science. The study utilized a treatment/comparison group pre-test/post-test design to compare assessment results for students receiving instruction on a topic using the SIE-provided modules to those not receiving instruction on that topic.

In Year Two of the SIE program, assessments were administered in both the Fall of 2007 and the Spring of 2008. In the Fall, assessments related to six modules were administered by Cohort 1 schools prior to and just after their implementation of their first module. In the Spring, 13 assessment scales were administered: Cohort 1 schools administered a second set of assessments for their second module and Cohort 2 schools administered assessments for their first module. Full results from the analyses of these data are reported separately[18]; highlights of the major findings follow.

Do students of teachers who participated in SIE professional development and who implemented the SIE-provided module on a topic exhibit greater achievement in science after instruction than students of teachers who participated in SIE professional development and who implemented a module in a different topic?

In all but one instance, the treatment and comparison groups of students were equivalent initially; for the exception, the comparison group outperformed the treatment group on the pre-test. On the post-test, controlling for pre-test scores and student demographics, treatment group students significantly outperformed comparison group students on 5 of the 6 assessment scales in the Fall of 2007 and on 11 of the 13 scales in the Spring of 2008. Effect sizes ranged from 0.18 to 1.16 standard deviations; most were at least 0.75 standard deviations.

Are there gender or race/ethnicity differences in student achievement, and if so, does use of an SIE-provided module reduce these differences?

The statistical models also examined whether achievement gaps existed by gender and race/ethnicity, and if there was adequate class-level variation, whether the use of the SIE-supported module changed the achievement gap. Because the number of students classifying themselves as any race/ethnic group other than White was small, these data were collapsed into two categories: White/Asian vs. non-Asian minority.[19]

White/Asian students outperformed non-Asian minority students on each scale at each pre-test administration. All but two of these achievement gaps did not change from pre- to post-test. On the *Levers and Pulleys* scale in the Fall of 2007, although both White/Asian and non-Asian

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[18] Banilower, E.R., Weis, A.M., & Rosenberg, S.L. (2008). Examining the Impact of *Science: It's Elementary* on Student Achievement: Analysis of Fall 2007 Data. Chapel Hill, NC: Horizon Research, Inc.

Rosenberg, S.L., Weis, A.M., & Banilower, E.R. (2008). Examining the Impact of *Science: It's Elementary* on Student Achievement: Analysis of Spring 2008 Data. Chapel Hill, NC: Horizon Research, Inc.

[19] Asian students typically outperform all other groups of students, and are often grouped with White students in these types of analyses.

minority students in treatment classes made large gains from pre- to post-test (compared to a minimal gain for students in the comparison classes), the rate of growth was greater for White/Asian students than for non-Asian minority students. A similar pattern was found for the *Rocks and Minerals* scale in the Spring of 2008.

In terms of gender gaps, male students outperformed female students on 3 of the 6 assessment scales in the Fall of 2007 and 5 of the 13 scales in the Spring of 2008. In addition, females outperformed males on one pre-test scale in the Fall of 2007. None of these gaps changed from pre- to post-test. However, post-test gender gaps were found on four scales that did not have pre-test gender gaps. In three cases, females outperformed males on the post-test in both treatment and comparison classes. In one case, males outperformed females on the post-test in treatment classes (although both groups had large gains); neither males nor females had substantial gains in the comparison classes.

Is there a relationship between extent of use of the SIE-provided modules and student achievement?

HRI examined whether the extent of module use was related to student achievement. A module use survey administered at the time of the post-test asked teachers to indicate which lessons from the module they had implemented, the amount of instructional time devoted to the topic, and the extent to which that instructional time was based on the module vs. other instructional materials.

HRI used a statistical technique called "cluster analysis" to classify classes into groups with distinct patterns of module use.[20] On the 15 scales for which there was variation in module use, HRI found a significant positive relationship between extent of module use and post-test scores on 7; no relationship was found for the other 8.

Is teachers' instruction more effective the second time they implement a module than the first time they implemented it?

By combining data collected in Year One and Fall of Year Two of SIE, it was possible to examine whether a "practice" effect exists. In other words, with no additional professional development, is instruction likely to be more effective when teachers are using a module for the second time? For this analysis, HRI selected only those teachers who used the same module in Year One and Year Two of the program.

On each scale, pre-test scores were significantly lower the second time teachers were implementing their module. This result may be due to the fact that the pre-test (and post-test as well) assessment was administered in the Fall of Year Two compared to the Spring of Year One. The cognitive and reading ability of elementary age children can change substantially in a short period, and the several month difference in when the assessment was administered may be responsible for the initial differences in scores.

[20] Cluster analysis is an exploratory statistical technique that groups cases on a combination of variables such that people within a group are similar to each other and relatively distinct from other groups. HRI employed the SPSS two-step cluster analysis procedure for this analysis using the percent of the module covered and the total instructional time spent on the topic variables. Percent of instructional time based on the module was not used to form the groups in the cluster analysis because the clustering solution resulted in more distinct differences among the groups when this variable was excluded.

Although pre-test scores were significantly lower the second time teachers implemented the module, post-test scores were not significantly different between the two times for 5 of the 6 scales (the exception being *Electric Circuits*), indicating that student growth was greater the second time teachers were implementing these modules. One possible explanation for these results is that teachers were able to use more of the module; another is that they spent more time on the topic. Although the sample size was too small to statistically examine whether extent of module use differs between first and second implementation, a descriptive analysis of the module use data revealed that teachers, on average, appeared to devote much more instructional time to the module during their second implementation than during their first implementation even though the two groups covered roughly the same number of lessons in the module.

Did Cohort 2 have greater gains their first time using the modules (in 2007–08) than Cohort 1 did their first time using the same modules (in 2006–07)?

HRI analyzed the assessment data related to the six original modules that were implemented by both cohorts (*Rocks and Minerals*; *Electric Circuits*; *Levers and Pulleys*; *Motion and Design*; *Mixtures and Solutions*; and *Variables*) to examine how changes in the initial module training provided by the SIE program may have affected student learning. Data from the first two years of the SIE program were combined for these analyses, and only students of treatment group teachers were included.

On each assessment scale related to these six modules, scores of students in the two cohorts were initially equivalent. Furthermore, there were no significant differences in pre- to post-test score gains between students of teachers in Cohort 1 and students of teachers in Cohort 2 for any of the modules. Thus, it does not appear that the changes made to the initial module training between the first and second year of the program led to changes in student achievement as measured by the assessments used in this study.

Is there a relationship between teacher participation in SIE Module Enrichment workshops and student achievement?

As part of the program design, SIE is offering teachers a second round of professional development on their modules. In October 2007, SIE piloted these module enrichment workshops for four modules with a subset of teachers participating in the program. The four modules were *Electric Circuits, Levers and Pulleys, Motion and Design,* and *Mixtures and Solutions*. However, it is important to note that teachers received their modules at the beginning of September 2007, and many teachers were several weeks into teaching the module before participating in a content deepening workshop. Thus, the opportunity for the workshops to have an impact on student achievement was limited.

Sixty-one teachers attended one of the pilot module enrichment workshops. However, not all of these teachers had participated in the initial training for the module; these teachers were not included in the analysis. To control for the possibility that the teachers attending the module enrichment workshops were not typical (i.e., they were less or more effective than most teachers), HRI decided to compare the Year One student achievement of teachers attending these sessions to those not attending.

There was no significant difference in pre-test scores by whether the teacher had attended a pilot module enrichment workshop, indicating initial equivalence of students of the two groups of teachers. In addition, there were no differences in Year One data between the two groups of teachers; in other words, teachers who attended the pilot module enrichment workshops in Year Two were not more or less effective than their colleagues in the year prior to attending one of these workshops.

Statistically, there was no significant difference in Year Two post-test scores between students of teachers who did and did not attend one of the pilot module enrichment workshops. However, it is interesting to note that the statistical test, although not meeting the criteria for significance, was close to being significant (an exact p-value of 0.054; p-values < 0.050 are typically considered significant), with students of attendees scoring 0.17 standard deviations higher on the post-test than students of non-attendees (controlling for pre-test scores and student demographic characteristics). It is not possible to determine whether this apparent difference is simply noise due to a small sample size or a real difference that this study lacked the statistical power to detect. Data to be collected in Year Three of the program may allow for a more definitive exploration of the impact of these module enrichment workshops on student achievement.

SUMMARY AND RECOMMENDATIONS

In Year Two, the SIE program can be credited with a number of accomplishments. The program has brought on board a second cohort of schools, in addition to increasing the services added to the first cohort. SIE has implemented Strategic Planning Institutes and Vision Conferences for Cohort 2 schools; provided three days of professional development to Cohort 2 teachers across the state; provided two days of professional development to Cohort 1 teachers on a second science module; provided two days of enrichment training to a subset of Cohort 1 teachers on their initial module; developed and delivered a leadership conference for teacher leaders; and delivered ready-to-use science modules to teachers participating in the program.

Overall, teachers, principals, and district staff have reported positive experiences with the SIE program. The Strategic Planning Institutes provided an opportunity for school teams to become familiar with science education reform and gave them the rare opportunity to work together on a plan for improving their science program. The Vision Conferences provided schools the opportunity to broaden the base of stakeholder support for science education reform.

Initial module training continues to be extremely well received by teachers and has generated a great deal of enthusiasm for teaching science from the modules, even among teachers who were skeptical of the program at the start. In addition, the professional development was successful at providing teachers with the knowledge and skills they needed to feel confident in implementing a science module for the first time.

The SIE program has implemented, and continues to refine, module enrichment training to help teachers become more purposeful in their teaching from the modules. Given the relative inexperience of elementary teachers with science, providing them with all of the knowledge they need is a tall order. Data from a pilot study indicate that SIE is having an impact on teacher content knowledge, though many teachers still have considerable room for growth in this area.

Classroom observations of teachers implementing the modules found that all of the observed lessons included some elements of effective practice, though only a few lessons managed to "put it all together." Common strengths of the lessons included involvement of students with key content as well as collegial interactions among students and respectful contact between the students and the teacher. Common areas of weakness included the extent of student intellectual engagement with and sense-making of the content. Students engaged in many hands-on activities, but the amount of intellectual rigor required of the students in most lessons was generally low. Many teachers made modifications to the instructional materials, often in the form of deleting probing questions or wrap-up discussions, which likely hindered students' opportunity to make sense of the target concepts.

Analyses of student achievement data provide evidence that the SIE program is having a positive effect on student learning in science. On 5 of the 6 assessment scales administered in the Fall of 2007, and on 11 of the 13 scales administered in the Spring of 2008, students receiving instruction using the SIE-provided module related to the scale scored significantly higher than students not receiving instruction from that module, controlling for pre-test scores and student demographics.

Although the SIE program has accomplished a great deal in its second year, as is the case with most programs in their early stages, a substantial amount of work remains to be done. In the spirit of a critical friend, HRI offers the following recommendations to assist the program in reflection and planning for the future.

- **Consider ways to support districts, schools, and teachers in developing articulated curricula that incorporate the SIE-provided modules and that also ensure that all state science standards will be addressed.**

  Although the majority of districts participating in SIE report having curriculum guides to direct teachers in the selection of science topics to teach (most of which were developed prior to SIE), evaluation data indicate that the enacted curriculum may not align well with Pennsylvania science standards. This lack of alignment is likely due to at least two factors. First, because of the emphasis on reading/language arts and mathematics due to high-stakes testing, science (and other non-tested subjects) has been deemphasized in schools. Second, elementary teachers often do not feel well prepared to teach science, consequently minimizing the amount of science they teach. Teachers also tend to cover the topics in which they feel comfortable and skip the others.

  Although the addition of a state science assessment has encouraged schools to include more science in their instructional programs, the fact that science is not counted towards Adequate Yearly Progress as part of No Child Left Behind may temper the impact of the science PSSA in this regard. Schools may find information on how they can reach literacy goals through the teaching of science helpful, as well as other ideas on how to make time for science instruction.

- **Continue to refine the initial module training provided to teachers, including strengthening teachers' vision of effective inquiry-based science instruction.**

  The professional development sessions HRI observed varied widely in regard to their focus on the science content and the content storyline in the modules. In some sessions, facilitators consistently made explicit connections between module activities and content goals, but in other sessions they did not. Thus, the program should consider building a structure into the training (i.e., some sense-making activity for each lesson in a module that all facilitators would be expected to do) to help ensure that all participants recognize the intended content in each lesson.

  Teachers would also benefit from understanding how the different science concepts in the module fit together and build towards the big ideas in science. Thus, the program should consider increasing the focus on the content storyline of a module in the initial module training. The program may also want to consider providing teachers with a hand-out that summarizes the concepts covered by the module and their interrelationships, as well as how each of the concepts is developed through the various module activities. Such a document would help teachers see how each activity in the module adds to student learning, reducing the likelihood that teachers pressed for time will skip key activities.

In addition, for teachers to effectively use inquiry-based teaching methods, they need to have a clear vision of what inquiry instruction is and how they can use the module in an inquiry-based manner. In the three-day initial module trainings HRI observed, the concept of inquiry was discussed during the first day's overview, but no clear vision of inquiry ever emerged. Understanding that the process of science and the nature of scientific knowledge rest upon drawing conclusions from evidence is key to effectively using inquiry in the classroom. Without this understanding, as well as a solid understanding of the concepts they are expected to teach, teachers are unlikely to be able to move from mechanical to purposeful implementation of a module

- **Classroom observations make it clear that most teachers need additional support to attain purposeful use of a module. The program wisely includes sustained professional development for teachers to help them develop the additional knowledge needed. The program should continue to refine these workshops.**

The module enrichment workshops have had a number of benefits for the attending teachers, including greater feelings of preparedness to implement the module and deeper understanding of the science content in the module. However, as with any new undertaking, these workshops would benefit from some refining.

Although the program has incorporated a number of activities in the module enrichment workshops that are rooted in what is known about effective professional development (e.g., examining student work, considering formative assessment strategies), many of the participating teachers were unable to fully engage with the activities. This lack of engagement was likely due to teachers not yet having a solid enough understanding of the science content of the module. Making the science content in the module more explicit in the initial module trainings will likely improve teachers' readiness for these types of activities. Teachers would also benefit from a somewhat deeper understanding of the content so they could effectively address questions students may raise or recognize and be able to redirect students when they begin traversing unproductive paths of inquiry.

In addition, it is important for the program to consider ways to tie the teachers' experiences in the module enrichment workshop more directly to the module. Because teachers are so pressed for time, they often need to see the direct application of what they are learning to their classroom practice. Making sure all of the workshop activities have a direct tie-in to the module, and helping teachers see these connections, will increase the likelihood that they will engage with these activities.

- **As the program continues to expand and bring aboard new schools and new professional development providers, it should consider creating artifacts that capture key elements of the program and its work.**

Creating a content storyline document that highlights the science concepts covered by a module, demonstrates the interrelationships among these concepts, and describes how each concept is developed via the module activities would likely benefit the program in several

ways.[21] First, this document would help guide the professional development around the module, ensuring that all of the important ideas are addressed. Second, this document would aid in the training of new professional development providers, ensuring consistency across the different sessions. Third, providing this document to teachers would give them a resource that they can refer back to during module implementation (which is often several weeks or months after the professional development), and help teachers move along the trajectory toward purposeful implementation of the module.

[21] Over time, as resources permit and for topics in which the research exists, a content storyline could be expanded to include a summary of the common student misconceptions related to the topic as well as tips for addressing them.

Appendix A

District Curriculum Alignment Questionnaire and Summary of Data

District Curriculum Alignment Questionnaire
Fall 2007

The Pennsylvania Department of Education (PDE) has requested that each district participating in the Science: It's Elementary program complete this questionnaire. The responses will help PDE decide what support to offer districts in future years, so please be candid. If you have any questions about this survey, please email Camille Warren at sie_eval@horizon-research.com or call (toll-free) 877-297-6829.

1. Does the district have a curriculum guide for science in grades K-6?

- Yes
- No

If you answered "no" to question #1 above, click here to skip to question #10.

2. What is this guide called in your district?

3. Was a process used to align the district K-6 science curriculum guide with the *Pennsylvania Academic Standards for Science and Technology and Environment and Ecology*?

-- select one --

If you answered "no" to question #3 above, click here to skip to question #7.

4. When was the most recent alignment process completed?

-- select one --

5. Who participated in the alignment process? (Select all that apply.)

- Superintendent
- Assistant superintendent
- District science specialist/supervisor
- Elementary school administrators
- Elementary school teachers
- Middle school science teachers
- High school science teachers
- University science educators
- University/business/industry scientists
- Other (please specify):

6. Briefly describe the process that was used to conduct the alignment:

7. **What are the functions of the district science curriculum guide?** (Select all that apply.)
   - ☐ To specify the grade(s) at which each Pennsylvania standard should be taught
   - ☐ To help the district select instructional materials
   - ☐ To help teachers decide what topics to cover/instructional materials to use
   - ☐ Other (please specify):

8. **How was the district science curriculum guide for K-6 science communicated to teachers when it was developed?** (Select all that apply.)
   - ☐ Each teacher responsible for teaching science in these grades received a copy of the district science curriculum.
   - ☐ The district provided staff development on the district science curriculum.
   - ☐ The district science curriculum was implicitly communicated through the selection of instructional materials.
   - ☐ Other (please specify):

9. **How is the district science curriculum guide for K-6 science communicated to teachers that have joined the district since it was developed?** (Select all that apply.)
   - ☐ New teachers receive a copy of the district science curriculum.
   - ☐ The district provides staff development to new teachers on the district science curriculum.
   - ☐ The district science curriculum is implicitly communicated through the instructional materials.
   - ☐ Other (please specify):

10. **Prior to participating in Science: It's Elementary, approximately what proportion of K-6 science instructional time in your district was based on each of the following types of instructional materials?** (Responses must add to 100%.)

Textbook-based instructional materials	-- proportion --
Module/kit-based instructional materials	-- proportion --
Other (e.g., trade books, district/teacher-developed materials) instructional materials	-- proportion --

11. **Which of the following best describes your district's policy regarding the selection of instructional materials for K-6 science?** (Select one.)
   - ○ a. All schools in the district are required to use the same instructional materials.
   - ○ b. The district provides a list of materials from which individual schools may select.

- ○ c. Individual schools select instructional materials without constraints by the district.
- ○ d. Individual teachers select the instructional materials they want to use.

If you selected "c" or "d" in question #11 above, click here to skip to question #15.

12. When were the current instructional materials for K-6 science adopted?

-- select one --

13. Who was involved in the selection of these materials? (Select all that apply.)

- ☐ Superintendent
- ☐ Assistant superintendent
- ☐ District science specialist/supervisor
- ☐ Elementary school administrators
- ☐ Elementary school teachers
- ☐ Middle school science teachers
- ☐ High school science teachers
- ☐ University science educators
- ☐ University/business/industry scientists
- ☐ Other (please specify): ______

14. Please describe the process by which these materials were selected, including how the alignment between the materials and the district science curriculum and/or the Pennsylvania Standards was assessed.

15. About how much professional development did a typical teacher receive on these instructional materials? (Select one.)

- ○ None
- ○ 6 or fewer hours
- ○ Between 7 and 12 hours
- ○ Between 13 and 18 hours
- ○ Between 19 and 24 hours
- ○ 25 or more hours

If you responded "none" to question #15 above, click here to skip to question #17.

16. Who provided the professional development? (Select all that apply.)

- ☐ The publisher
- ☐ District science specialist/supervisor
- ☐ Other district personnel (please specify): ________
- ☐ ASSET, Inc.
- ☐ Other (please specify): ________

17. **When will the next adoption for K-6 science instructional materials take place?** (Select one.)
   - ○ 2007
   - ○ 2008
   - ○ 2009
   - ○ 2010
   - ○ 2011
   - ○ Other, please specify: ________

PDE has also asked that we interview a subset of the people responding to this survey. Please provide the following information so that we may contact you if you are selected for an interview.

Name: ________

Title: ________

Phone: ________

E-mail: ________

Best times to contact:

Submit Form | Clear

Number of valid questionnaires

	N
Total Participants	48

Q1

	Total		No	Yes
	Valid N	Missing N	Percent	Percent
q1: Does the district have a curriculum guide for science in grades K–6?	48	0	31	69

Q3

	Total		No	Yes
	Valid N	Missing N	Percent	Percent
q3: Was a process used to align the district K–6 science curriculum guide with the Pennsylvania Academic Standards for Science and Technology and Environment and Ecology?	33	0	15	85

Table includes only those schools that have a curriculum guide for science in grades K-6 (Q1).

Q4

	Total		2001 or earlier	2002	2003	2004	2005	2006	2007
	Valid N	Missing N	Percent	Percent	Percent	Percent	Percent	Percent	Percent
q4: When was the most recent alignment process completed?	28	0	18	11	11	4	7	32	18

Table includes only those schools that used a process to align their district K-6 science curriculum guide with the state standards. (Q3)

Q5

	Total		No	Yes
Who participated in the alignment process?	Valid N	Missing N	Percent	Percent
q5a: Superintendent	28	0	86	14
q5b: Assistant superintendent	28	0	75	25
q5c: District science specialist/supervisor	28	0	71	29
q5d: Elementary school administrators	28	0	32	68
q5e: Elementary school teachers	28	0	7	93
q5f: Middle school science teachers	28	0	39	61
q5g: High school science teachers	28	0	54	46
q5h: University science educators	28	0	89	11
q5i: University/business/industry scientists	28	0	100	0
q5j: Other (please specify):	28	0	68	32

Table includes only those schools that used a process to align their district K-6 science curriculum guide with the state standards (Q3).

Q7

What are the functions of the district science curriculum guide?	Total		No	Yes
	Valid N	Missing N	Percent	Percent
q7a: To specify the grade(s) at which each PA standard should be taught	33	0	30	70
q7b: To help the district select instructional materials	33	0	52	48
q7c: To help teachers decide what topics to cover/instructional materials to use	33	0	15	85
q7d: Other (please specify):	33	0	73	27

Table includes only those schools that have a curriculum guide for science in grades K-6 (Q1).

Q8

How was the district science curriculum guide for K–6 science communicated to teachers when it was developed?	Total		No	Yes
	Valid N	Missing N	Percent	Percent
q8a: Each teacher responsible for teaching science in these grades received a copy of the district science curriculum.	33	0	18	82
q8b: The district provided staff development on the district science curriculum.	33	0	61	39
q8c: The district science curriculum was implicitly communicated through the selection of instructional materials.	33	0	64	36
q8d: Other (please specify):	33	0	76	24

Table includes only those schools that have a curriculum guide for science in grades K-6 (Q1).

Q9

How is the district science curriculum guide for K–6 science communicated to teachers that have joined the district since it was developed?	Total		No	Yes
	Valid N	Missing N	Percent	Percent
q9a: New teachers receive a copy of the district science curriculum.	33	0	30	70
q9b: The district provides staff development to new teachers on the district science curriculum.	33	0	67	33
q9c: The district science curriculum is implicitly communicated through the instructional materials.	33	0	58	42
q9d: Other (please specify):	33	0	73	27

Table includes only those schools that have a curriculum guide for science in grades K-6 (Q1).

Q10

Prior to participating in Science: It's Elementary, approximately what proportion of K-6 science instructional time in your district was based on each of the following types of instructional materials?	Total		0	10	20	30	40	50	60	70	80	90	100
	Valid N	Missing N	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
q10a: Textbook-based instructional materials	46	2	9	11	2	7	7	13	13	4	15	17	2
q10b: Module/kit-based instructional materials	44	4	25	27	9	7	0	7	7	5	5	7	2
q10c: Other (e.g., trade books, district/teacher-developed materials) instructional materials	43	5	7	37	19	19	5	7	2	0	0	0	5

Q11

	Total		All schools in the district are required to use the same instructional materials.	The district provides a list of materials from which individual schools may select.	Individual schools select instructional materials without constraints by the district.	Individual teachers select the instructional materials they want to use.
	Valid N	Missing N	Percent	Percent	Percent	Percent
q11: Which of the following best describes your district's policy regarding the selection of instructional materials for K–6 science?	48	0	56	19	13	13

Q12

	Total		2001 or earlier	2002	2003	2004	2005	2006	2007
	Valid N	Missing N	Percent	Percent	Percent	Percent	Percent	Percent	Percent
q12: When were the current instructional materials for K–6 science adopted?	36	0	33	14	6	6	17	14	11

Table includes only those schools whose districts select the instructional materials or provide a list of materials from which schools may choose (Q11).

Q13

Who was involved in the selection of these materials?	Total		No	Yes
	Valid N	Missing N	Percent	Percent
q13a: Superintendent	36	0	75	25
q13b: Assistant superintendent	36	0	67	33
q13c: District science specialist/supervisor	36	0	69	31
q13d: Elementary school administrators	36	0	22	78
q13e: Elementary school teachers	36	0	11	89
q13f: Middle school science teachers	36	0	69	31
q13g: High school science teachers	36	0	81	19
q13h: University science educators	36	0	92	8
q13i: University/business/industry scientists	36	0	97	3
q13j: Other (please specify):	36	0	81	19

Table includes only those schools whose districts select the instructional materials or provide a list of materials from which schools may choose (Q11).

Q15

	Total		None	6 or fewer hours	Between 7 and 12 hours	Between 13 and 18 hours	Between 19 and 24 hours	25 or more hours
	Valid N	Missing N	Percent	Percent	Percent	Percent	Percent	Percent
q15: About how much professional development did a typical teacher receive on these instructional materials?	48	0	31	44	15	6	4	0

Q16

	Total		No	Yes
Who provided the professional development?	Valid N	Missing N	Percent	Percent
q16a: The publisher	33	0	42	58
q16b: District science specialist/supervisor	33	0	88	12
q16c: Other district personnel (please specify):	33	0	85	15
q16d: ASSET, Inc.	33	0	73	27
q16e: Other (please specify):	33	0	76	24

Table includes only those schools where a typical teacher received some professional development on the instructional materials (Q15).

Appendix B

Selected Cohort 2 Teacher Curriculum Survey Results

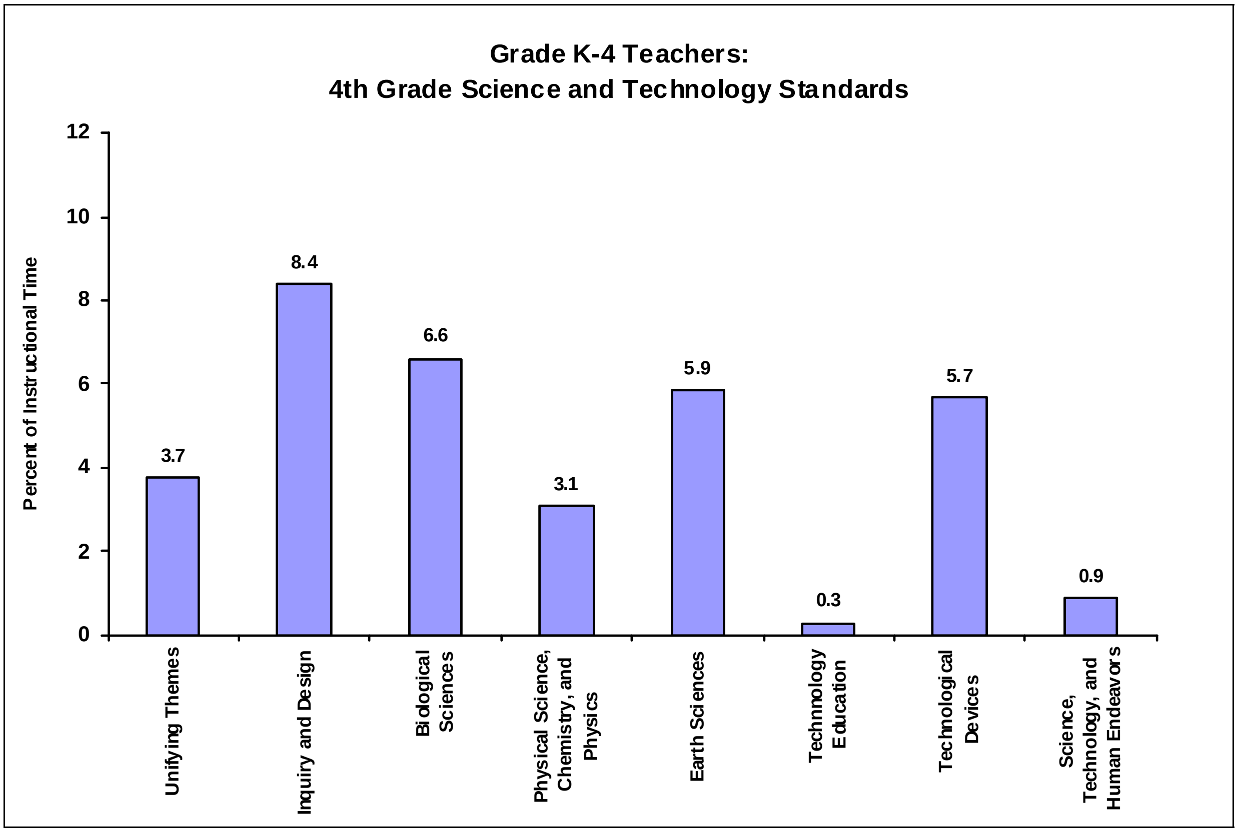

Grade K-4 Teachers:
4th Grade Science and Technology Standards
Percent of Instructional Time
12
10
8
6
4
2
0
3.7
8.4
6.6
3.1
5.9
0.3
5.7
0.9
Unifying Themes
Inquiry and Design
Biological Sciences
Physical Science, Chemistry, and Physics
Earth Sciences
Technnology Education
Technological Devices
Science, Technology, and Human Endeavors

Figure B-1

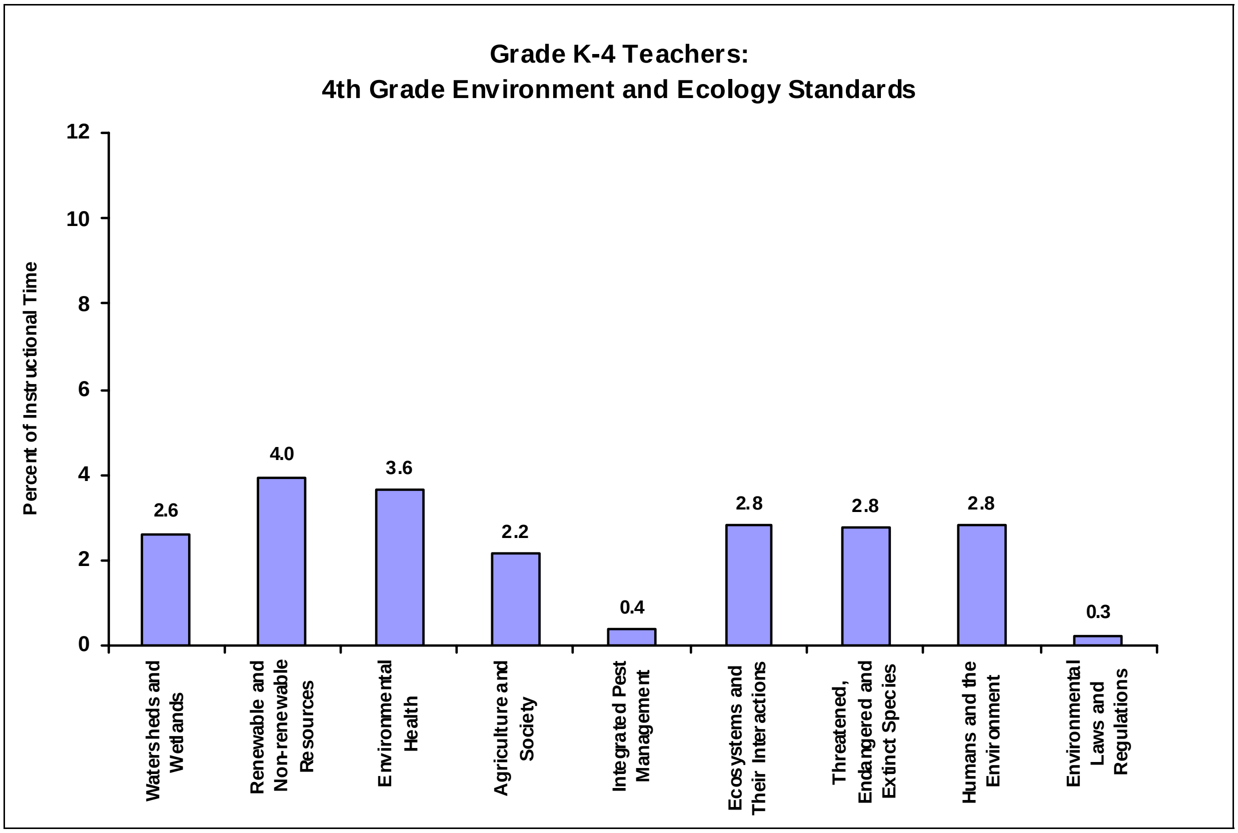

Grade K-4 Teachers:
4th Grade Environment and Ecology Standards
Percent of Instructional Time
0
2
4
6
8
10
12
2.6
4.0
3.6
2.2
0.4
2.8
2.8
2.8
0.3
Watersheds and Wetlands
Renewable and Non-renewable Resources
Environmental Health
Agriculture and Society
Integrated Pest Management
Ecosystems and Their Interactions
Threatened, Endangered and Extinct Species
Humans and the Environment
Environmental Laws and Regulations

Figure B-2

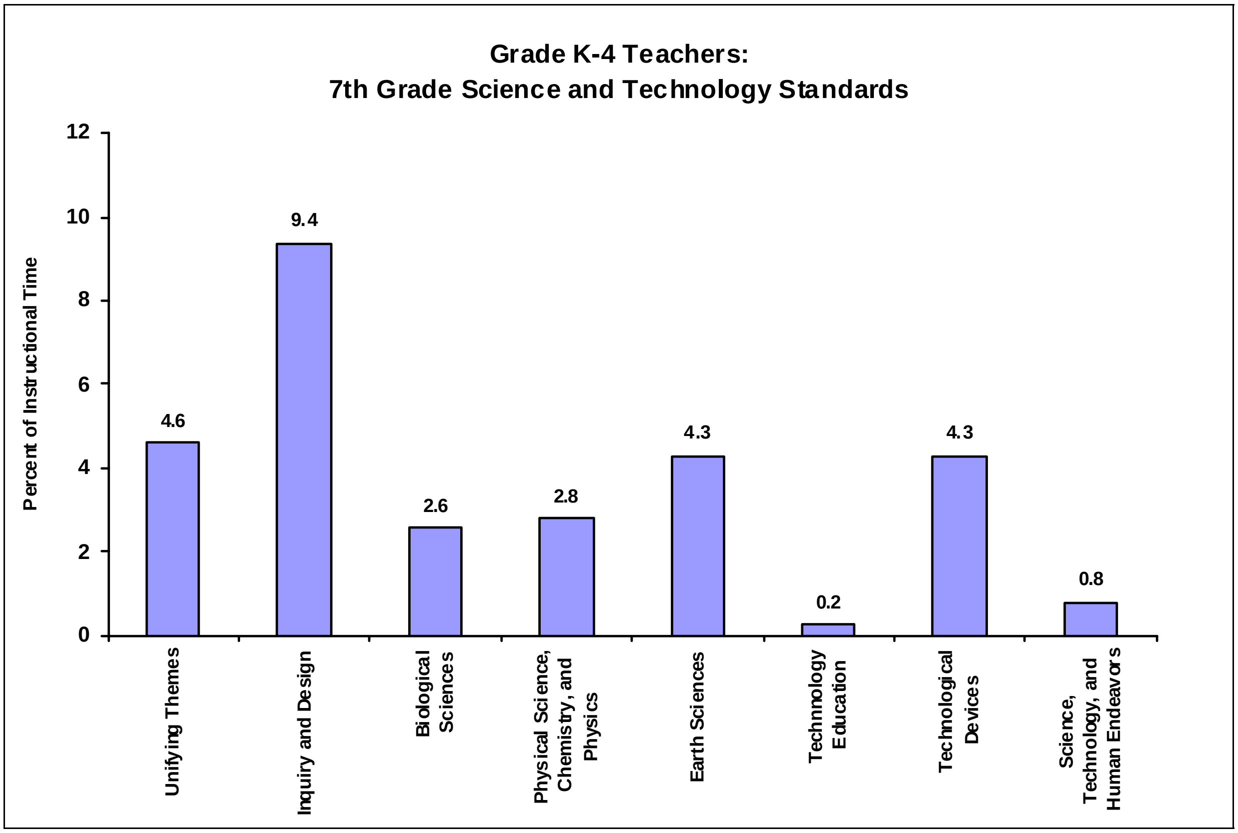

Grade K-4 Teachers:
7th Grade Science and Technology Standards
Percent of Instructional Time
12
10
8
6
4
2
0
4.6
9.4
2.6
2.8
4.3
0.2
4.3
0.8
Unifying Themes
Inquiry and Design
Biological Sciences
Physical Science, Chemistry, and Physics
Earth Sciences
Technology Education
Technological Devices
Science, Technology, and Human Endeavors

Figure B-3

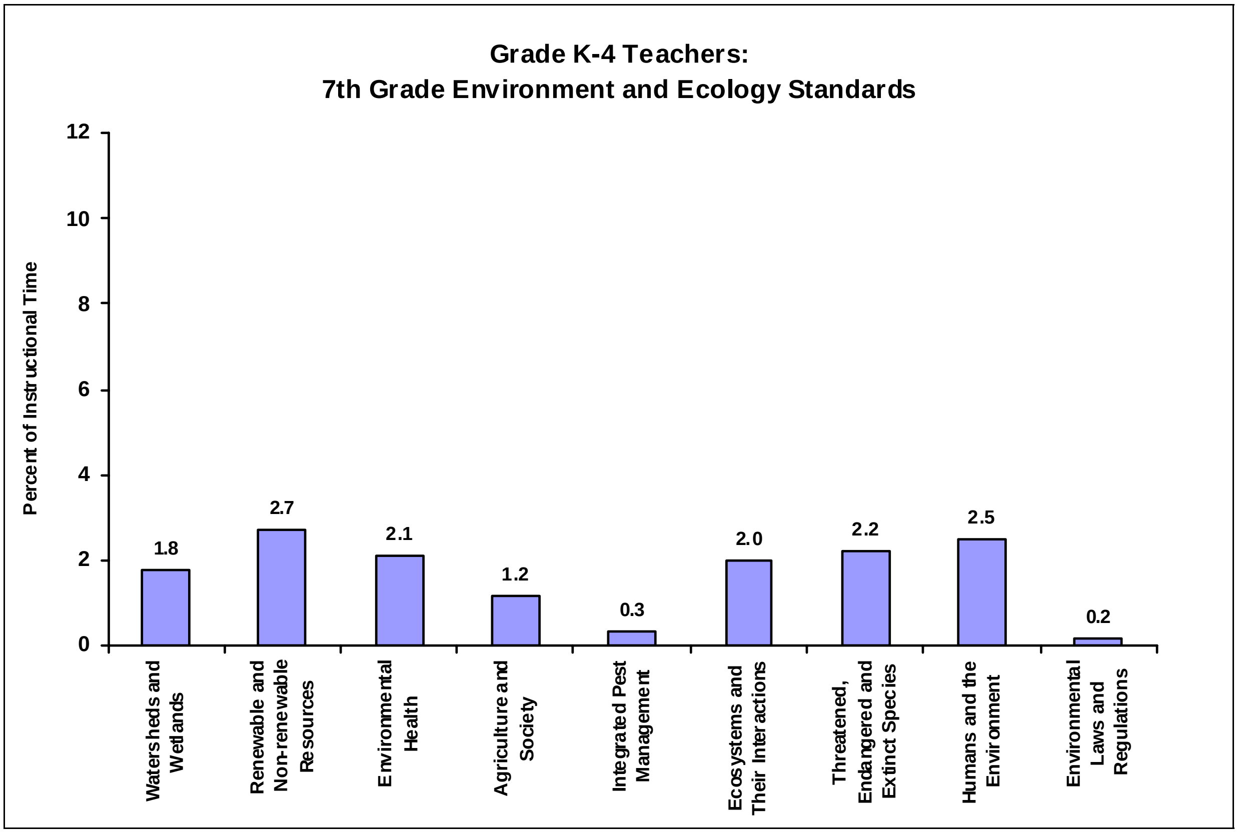

Grade K-4 Teachers:
7th Grade Environment and Ecology Standards
Percent of Instructional Time
12
10
8
6
4
2
0
1.8
2.7
2.1
1.2
0.3
2.0
2.2
2.5
0.2
Watersheds and Wetlands
Renewable and Non-renewable Resources
Environmental Health
Agriculture and Society
Integrated Pest Management
Ecosystems and Their Interactions
Threatened, Endangered and Extinct Species
Humans and the Environment
Environmental Laws and Regulations

Figure B-4

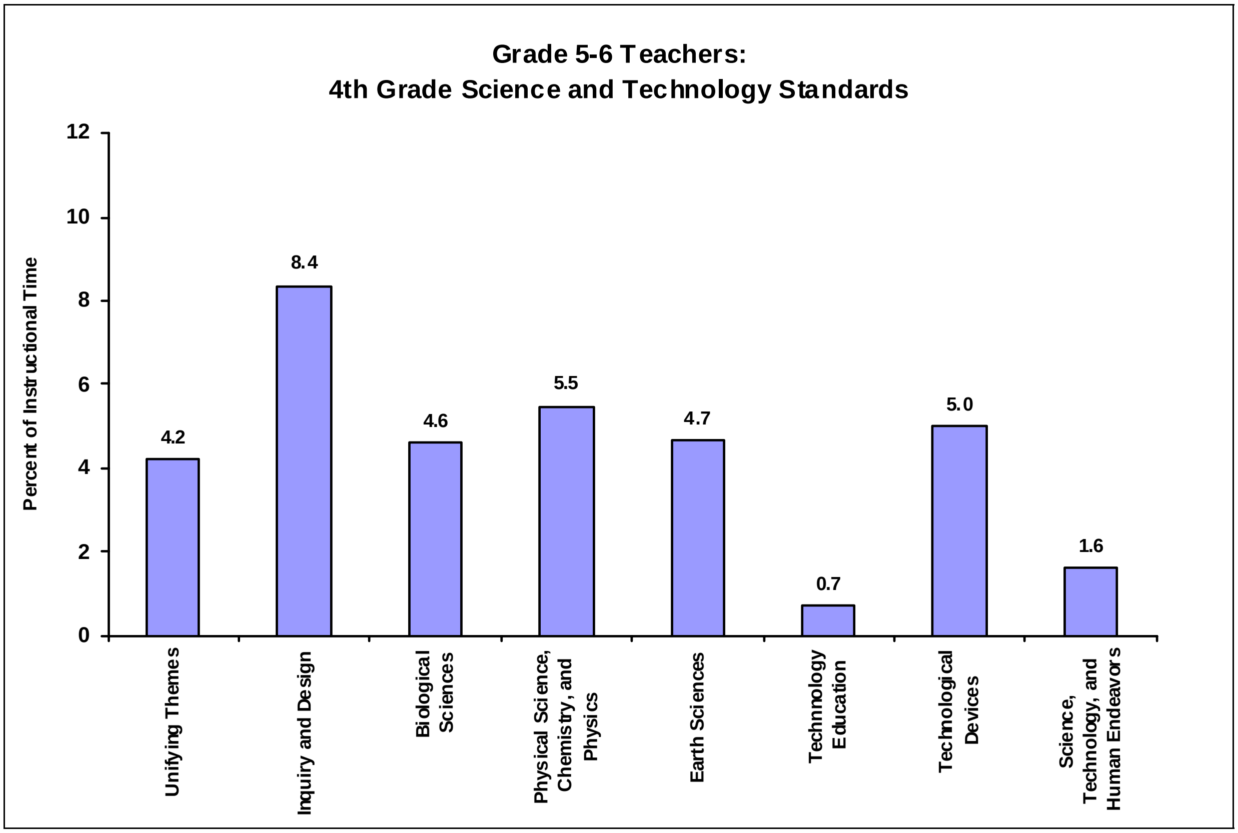
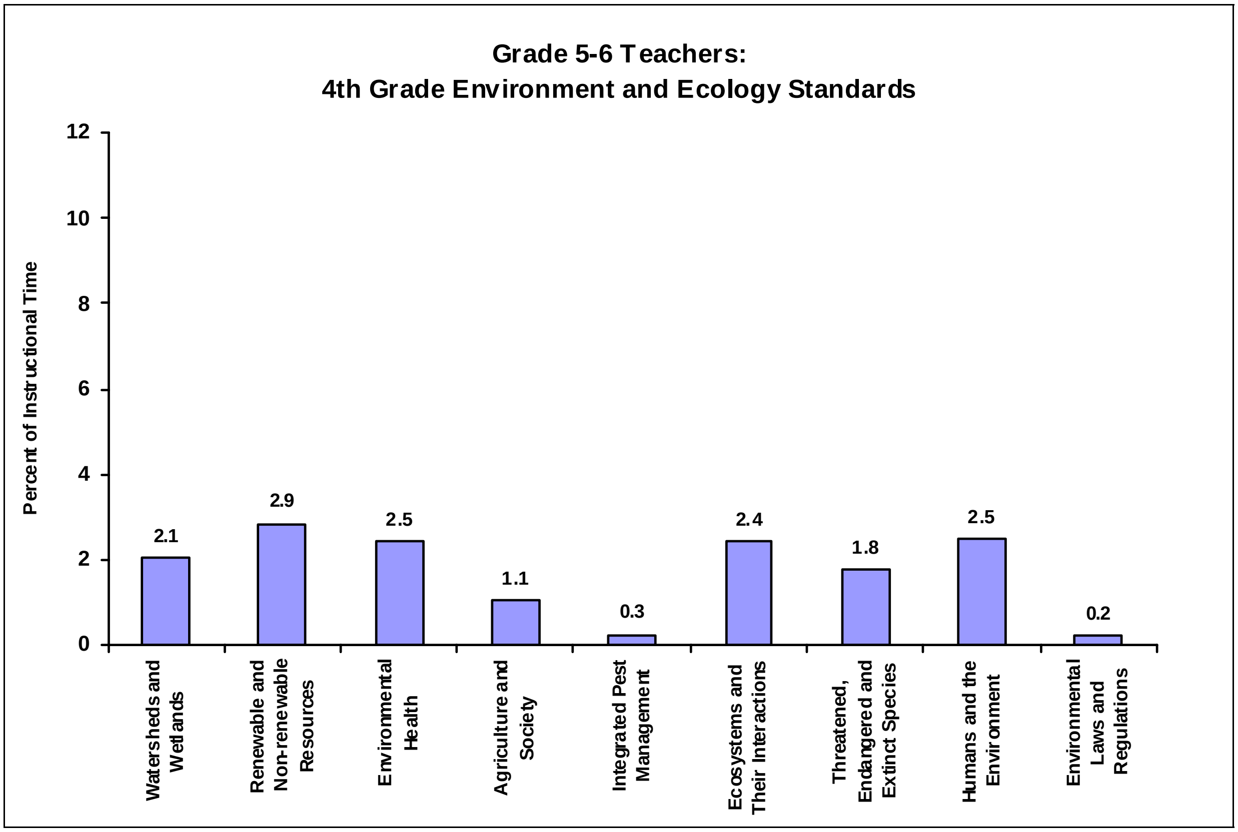

Grade 5-6 Teachers:
4th Grade Science and Technology Standards
Percent of Instructional Time
12
10
8
6
4
2
0
4.2
8.4
4.6
5.5
4.7
0.7
5.0
1.6
Unifying Themes
Inquiry and Design
Biological Sciences
Physical Science, Chemistry, and Physics
Earth Sciences
Technnology Education
Technological Devices
Science, Technology, and Human Endeavors

Figure B-5


Grade 5-6 Teachers:
4th Grade Environment and Ecology Standards
Percent of Instructional Time
12
10
8
6
4
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2.5
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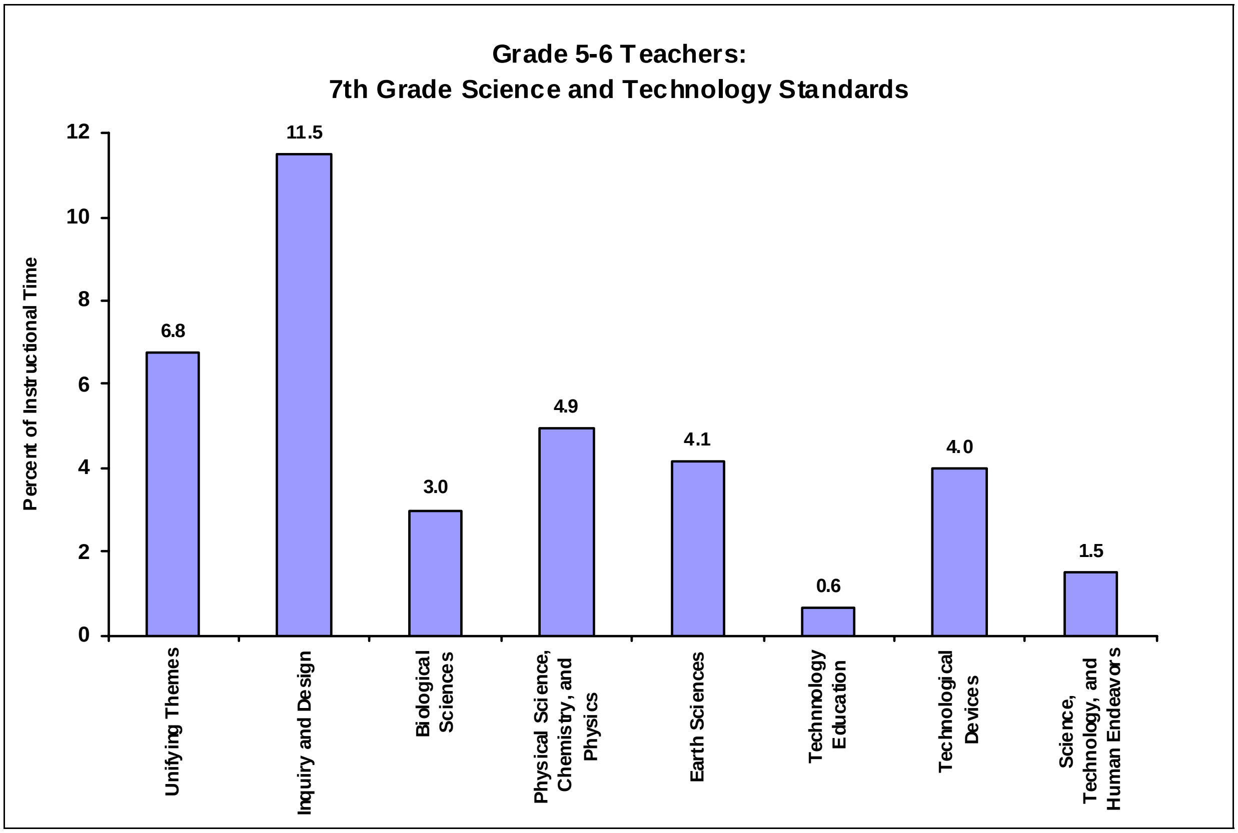
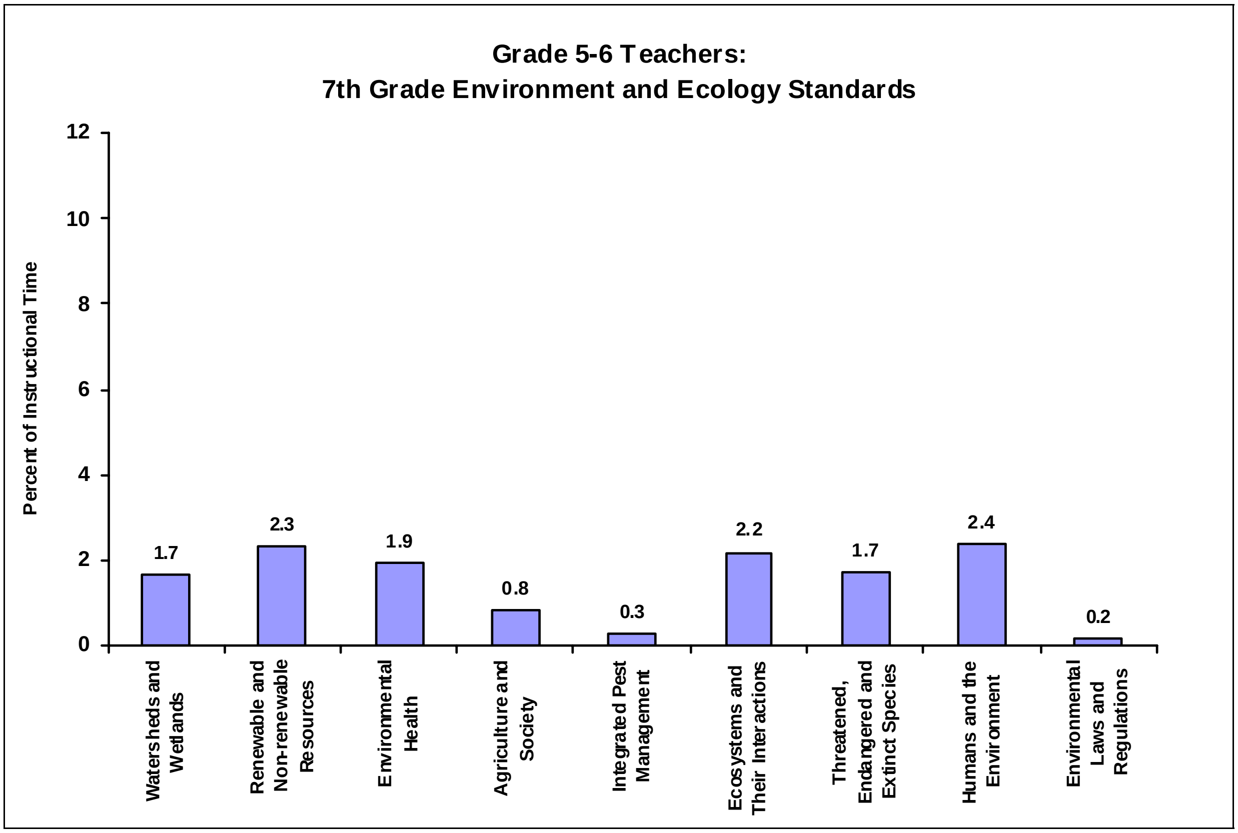
Watersheds and Wetlands
Renewable and Non-renewable Resources
Environmental Health
Agriculture and Society
Integrated Pest Management
Ecosystems and Their Interactions
Threatened, Endangered and Extinct Species
Humans and the Environment
Environmental Laws and Regulations

Figure B-6



Grade 5-6 Teachers:
7th Grade Science and Technology Standards
Percent of Instructional Time
12
10
8
6
4
2
0
6.8
11.5
3.0
4.9
4.1
0.6
4.0
1.5
Unifying Themes
Inquiry and Design
Biological Sciences
Physical Science, Chemistry, and Physics
Earth Sciences
Technology Education
Technological Devices
Science, Technology, and Human Endeavors

Figure B-7


Grade 5-6 Teachers:
7th Grade Environment and Ecology Standards
Percent of Instructional Time
12
10
8
6
4
2
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1.7
2.3
1.9
0.8
0.3
2.2
1.7
2.4
0.2
Watersheds and Wetlands
Renewable and Non-renewable Resources
Environmental Health
Agriculture and Society
Integrated Pest Management
Ecosystems and Their Interactions
Threatened, Endangered and Extinct Species
Humans and the Environment
Environmental Laws and Regulations

Figure B-8

Appendix C

Composite Definitions

To facilitate the reporting of large amounts of survey data, and because individual questionnaire items are potentially unreliable, groups of survey questions that measure similar ideas can be combined into "composites." Each composite represents an important construct related to science teaching or professional development. Cronbach's Coefficient Alpha is a measure of the reliability of a composite (i.e., the extent to which the items appear to be measuring the same construct). A Cronbach's Alpha of 0.6 is considered acceptable, 0.7 fair, 0.8 good, and 0.9 excellent.

Each composite is calculated by summing the responses to the items associated with that composite and then dividing by the total points possible. In order for the composites to be on a 100-point scale, the lowest response option on each scale was set to 0. As a result, someone who marks the lowest point on every item in a composite receives a score of 0, and someone who marks the highest point on every item receives a score of 100. It also assures that 50 is the true mid-point. The denominator for each composite is determined by computing the maximum possible sum of responses for a series of items and dividing by 100; e.g., a nine-item composite where each item is on a scale of 0–4 would have a denominator of 0.36.

Table C-1
Composite: Teacher Perceptions of Pedagogical Preparedness

Preparedness to:	**Post-PD (Prior)**	**Post-PD (Now)**	**End-of-Year**
Use the inquiry-based teaching strategies embedded in the SIE module	Q7a-p	Q7a-n	Q7a
Use science notebooks to support student learning of the content in the SIE module	Q7b-p	Q7b-n	Q7b
Use the FERA (Focus, Explore, Reflect, Apply) and 5 E (Engagement, Exploration, Explanation, Elaboration, Evaluation) Learning Cycles to teach using the SIE module	Q7c-p	Q7c-n	Q7c
Manage the logistics of the SIE module	Q7d-p	Q7d-n	Q7d
Handle classroom management issues with the SIE module	Q7e-p	Q7e-n	Q7e
Use questioning strategies to elicit student thinking about the science concepts in the module.	Q7f-p	Q7f-n	Q7f
Examine student work to assess student thinking about the science concept in the module.	Q7g-p	Q7g-n	Q7g
Teach the science concepts addressed in the module.	Q7h-p	Q7h-n	Q7h
Number of Items in Composite	**8**	**8**	**8**
Reliability (Cronbach's Coefficient Alpha)	**0.96**	**0.93**	**0.92**

Table C-2
Composite: Teacher Perceptions of Pedagogical Content Knowledge

Understanding of:	**Post-PD (Prior)**	**Post-PD (Now)**	**End-of-Year**
Student learning goals (big ideas) in the SIE module	Q6a-p	Q6a-n	Q8a
Science content in the SIE module at the level that the students are expected to learn it	Q6b-p	Q6b-n	Q8b
Science content in the SIE module at a deeper level than what students are expected to learn	Q6c-p	Q6c-n	Q8c
Ideas (either correct or incorrect) that students are likely to have about the content in the SIE module before instruction	Q6d-p	Q6d-n	Q8d
How the activities in the module connect conceptually with one another.	Q6e-p	Q6e-n	Q8e
How the activities in the module contribute to understanding the big ideas of the module.	Q6f-p	Q6f-n	Q8f
Real-world connections to the science content in the module.	Q6g-p	Q6g-n	Q8g
Number of Items in Composite	**7**	**7**	**7**
Reliability (Cronbach's Coefficient Alpha)	**0.96**	**0.92**	**0.93**